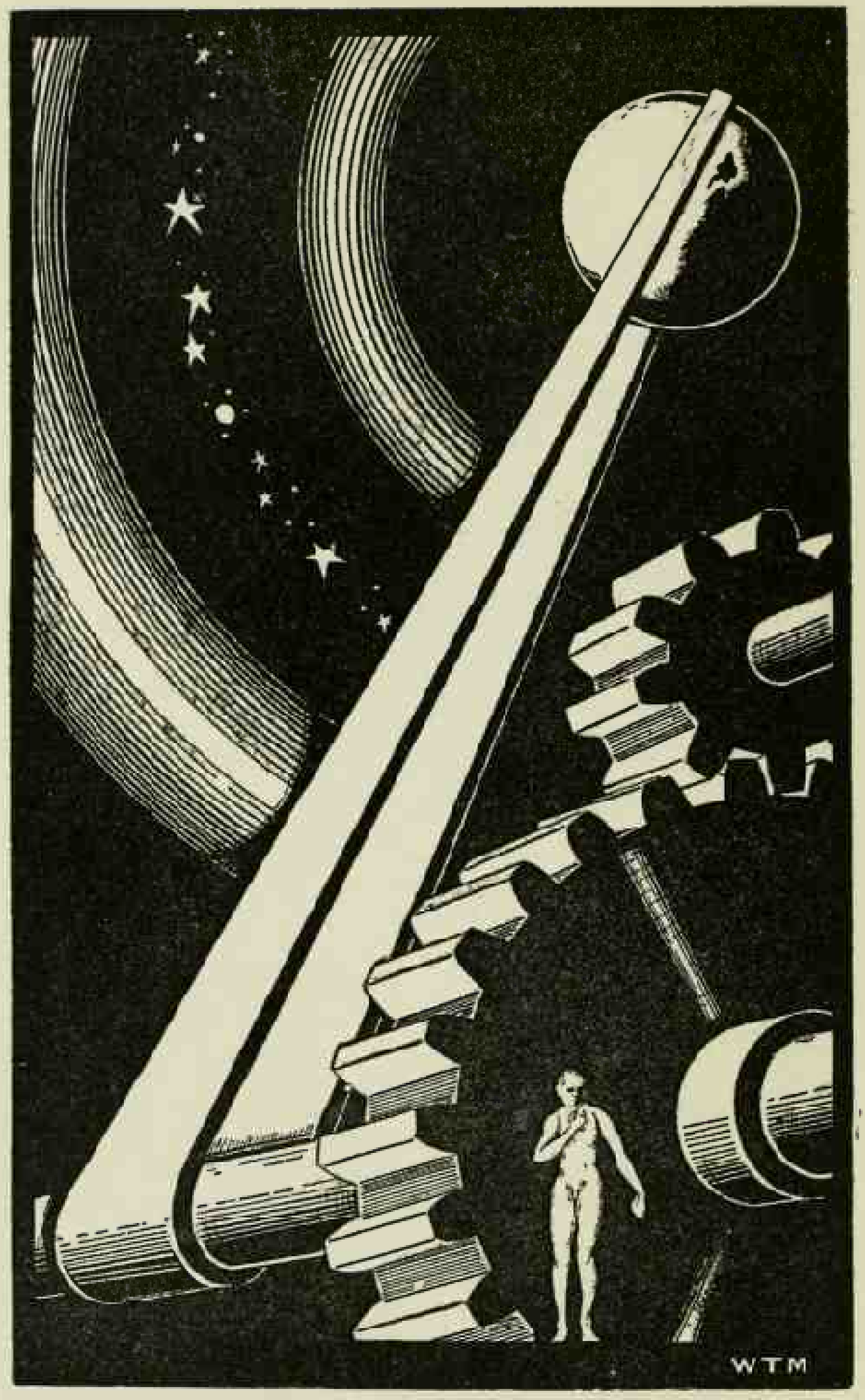
MEN AND MACHINES

STUART CHASE

PHILURA GOULD BALDWIN
MEMORIAL LIBRARY

BALDWIN-WALLACE COLLEGE
UNITED 1913
FOUNDED
1845
BEREA, OHIO

Accession No. 12175
Class 338.4
Book CA87
Volume


WTM

Philura Gould Baldwin
Memorial Library

MEN AND MACHINES

By STUART CHASE

ILLUSTRATED BY
W. T. MURCH

THE MACMILLAN COMPANY
NEW YORK MCMXXXVII

338.4
CA87

CONTENTS

CHAPTER PAGE
I. SLAVES AND PHILOSOPHERS . . . 1
II. THE ANATOMY OF MACHINERY . . . 22
III. MACHINES OF THE ANCIENTS . . . 42
IV. FROM JAMES WATT TO THE MECHANICAL MAN 64
V. FROM JAMES WATT TO THE MECHANICAL MAN (*Continued*) 85
VI. THE WALL OF STEEL 108
VII. UNDER THE LIFTING SMOKE . . . 124
VIII. ROBOTS 142
IX. SKILLS 169
X. SAVING LABOUR 183
XI. JOBS 204
XII. THE FLOOD OF GOODS 218
XIII. SKYSCRAPERS 240
XIV. PLAYGROUNDS 253
XV. ONE DEAD LEVEL 266
XVI. LEANING TOWERS 286
XVII. THE TWO-HOUR WAR 307
XVIII. THE BALANCE SHEET 318
XIX. A BILLION WILD HORSES 337
SELECTED BIBLIOGRAPHY 349
INDEX 351

12175

MEN AND MACHINES

CHAPTER I

SLAVES AND PHILOSOPHERS

CERTAIN philosophers hold that machinery is enslaving us. I am not a machine tender, but first and last I encounter a good many mechanisms in a day's march, particularly when that day is spent in a city so large and so complicated that it could never have been built by human muscle. Before analyzing the extent of serfdom in others, it might be well to determine how far I am myself a slave.

The first thing that I hear in the morning is a machine—a patented alarm clock. It calls and I obey. But if I do not feel like obeying, I touch its back, and it relapses humbly into silence. Thus we bully each other, with the clock normally leading by a wide margin. (Once, however, I threw a clock out of the window, and it never bullied anyone again.)

I arise and go into the bathroom. Here I take up a second mechanism, and after inserting a piece of leather between its rollers, move it briskly up and down before proceeding to scrape my face with it. I turn various faucets and a mixing valve, and a nickel dial studded with little holes showers me with water. Depending on the season, I may snap on electric lights and an electric heater. Downstairs, if it chances to be either the first or the fifteenth day of the month, I take a can with a very long nose, and oil an electric motor which blows petroleum into my furnace, a motor which runs the washing machine, and a motor which operates my refrigeration engine. Meanwhile an electrical range is cooking my breakfast, and on the table slices of bread are being heated by an electrical toaster which makes a buzzing sound in its vitals, and then suddenly splits open when the toast is browned to a turn. If time allows, I may play a little tune on the piano which stands near the breakfast table, noting the delicate system of levers and hammers upon which the mechanism is based. Before I leave the house, the whine of the vacuum cleaner is already in my ears.

I go to the garage, and by proper and sometimes prolonged manipulations, start explosions in six cylinders of an internal combustion engine. With foot and hand, I put the revolving crank shaft in touch with the rear wheels, and proceed to pilot the whole mechanism to the station, passing or halting before three sets of automatic signal lights as I go. At the station, I cease operating machinery and resign myself to another man's operation of an enormous secondary mover, fed by a third rail from a hydroelectric turbine at Niagara Falls. I cannot glance out of the window without seeing a steamboat on the Hudson River, a steam shovel on the speculative real estate development, a travelling crane on a coal dock, or a file of motor cars on any street. Every so often comes the faint roar and silver glint of an airplane, winging its way above the river.

Arrived at the metropolitan terminal, I buy a package of cigarettes by depositing a coin in a machine which hands me matches and says, "Thank you; it's toasted." I then spend ten minutes walking just three blocks. If I tried to shorten this time appreciably, I should most certainly be killed by a machine. Instead, I look down into an enormous pit where the day before yesterday, according to the best of my recollection, there stood a solid brownstone house. Now it is an inferno of swarming men, horses, trucks, pile drivers, rock drills, steam shovels, clacking pumps, and preparation for erecting a gigantic steel derrick. From across the street comes the deafening rat-tat-too of riveters.

I enter my office building and a machine shoots me vertically towards the roof. I step into a large room, stopping for a moment on the threshold to sort out the various mechanical noises which lend a never-ending orchestral accompaniment to all my working hours in town. The sputter of typewriters; the thud as the carriage is snapped back; the alternate rings and buzzes of the telephone switchboard; the rhythmic thump of the adding machine; the soft grind of a pencil sharpener; the remorseless clack of the addressograph and the mimeograph. During the day I make and receive about twenty calls upon the telephone. I crank an adding machine from time to time. I may operate a typewriter for an hour or so. Meanwhile my eye can seldom stray long from my watch, if the day is to be got through with at all.

To go up or downtown I use one of the three horizontal levels of transportation which the city affords. As a profound melancholia always accompanies a trip on the lowest, I endeavour to use the upper two exclusively. Many of my fellow citizens do the same, particularly since a score of them were killed at Times Square the other day. Killed in the rush hour, like beeves in the Chicago stockyards; except that the packers put no more animals into a pen than can go in.

In the evening I reverse the morning process. At home, I may sit for a few moments beneath a machine which gives off ultra-violet rays, or I may dance to strains of a machine which runs a steel needle over a corrugated rubber disc, and for the governor of whose delicate mechanism we are indebted to James Watt. For days at home, direct contact is limited to running the motor car and making minor repairs upon it; answering the telephone; using, hearing, tinkering with the various household so-called labour savers—particularly the plumbing system.

In the summer, by way of contrast, I may spend weeks in a mountain camp, where the only mechanisms are the motor car, the telephone, and a remarkably temperamental contrivance for pumping water. Year in year out I doubt if my direct contact with machines averages much over two hours a day. When I go to town, the ratio runs considerably higher; when I stay at home, an hour would certainly cover it; in the summer, an hour would be too much.

So far as I am aware, no permanently evil effects befall me by virtue of these two mechanical hours. I suffer from no prolonged monotonies, fatigues or repressions. The worst moments are dodging street traffic and hearing its roar, riding in the subway, changing tires and cleaning out the incinerator. When the telephone becomes unduly obstreperous, I go away and leave it. By far the most fatiguing noise in my office is the scraping of chair legs on the hard composition floor—and chairs I believe antedated Watt. All the depressions that I suffer from direct contact with machinery are certainly compensated for by the helping hand it holds out to me—a calculator for figuring percentages, an oil heater which requires no stoking, a reading lamp which does not have to be trimmed and filled, an elongated radius of travel possibilities, a car for errands, together with the genuine thrill which often comes from controlling its forty horses.

I do not feel like a slave, though of course I may be one all the same. Clocks and watches are hard masters but so they always have been; there is nothing new or ominous about their tyranny. No individual living in a social group is ever free, but I wonder if these two mechanized hours have put more shackles on me than were to be found on the average citizen of Rome two thousand years ago, or of China today—cultures innocent of engines both. As I look about the United States, the most mechanized nation under the sun, I have reason to believe—and later will bring in the statistical proof—that the number of those bound intimately to the rhythm of the machine is a small percentage of the total population, while there are probably more people with contacts remoter than mine than with closer contacts. In other words, I am more mechanized than the majority of my fellow citizens, and, needless to say, far less mechanized than a minority thereof.

Meanwhile an astonishing, not to say disturbing, enlargement has taken place in our several human faculties; an access of power which seems strangely out of place in a race of serfs. Perhaps the best way to indicate it is to sketch a contrast.

One day I came upon an urchin in the middle of the Russian steppe. He watched us change a tire on the first motor car that he had ever seen. We drove him to his village, where all his friends and relatives stood boggle-eyed at our approach. That boy and that village were carrying on substantially as their forebears had done for a thousand years—the timeless rural economy of the spade, the hand loom and the ox. Growing to manhood there, he will in all probability continue to carry on for years to come, despite the commendable exertions of his Government.

He will use his eyes, ears, senses and muscles according to the same biological limitations which the builders of Stonehenge knew—which mankind has always known. His strength will be that of his own back; his sensitiveness that of his own nerves. For heavy loads from time to time a horse or an ox may help him. The power will be that of living organisms, no more.

Suppose that boy is brought to New York. Suppose, as has been the case with many Russians, he develops into a talented scientist. Suppose he becomes, for the moment, a generic figure for the scientist and engineer, familiar with the main aspects of modern technology and capable of operating its mechanical devices.

Suddenly the biological limitations of the peasant youth are banished. He begins to grow in all directions—physical and mental. His eye at the lens of a telescope becomes one million times stronger; his voice before a microphone can be heard ten thousand miles away. His ear picks up the vibrations of a woman's singing in another continent. Although his naked thumb can measure hardly to the thickness of its nail, with an electron tube micrometer he can judge space to one billionth of an inch. An intricate differential equation of the second order may take him weeks to solve, but with the new integrating machine invented by professors of the Massachusetts Institute of Technology, he can have his answer in an hour. Indeed, he can have answers to problems too difficult for any human mind to solve. With his own hand he can write fifty words a minute, but with a rotary press he can, in an equal time, lay down two hundred thousand words.

With his back he can sustain perhaps one thousand pounds and carry half that weight for a short distance. With the electrical controls of a travelling crane he can lift four hundred and thirty tons and carry it as far as the mechanism extends. With his fist he can perhaps knock down a man; with a steam hammer he can crush a three-foot bar of steel as though it were soft clay. He picks up a stone and throws it a few hundred feet at most; he presses a button on a siege gun and throws a ton of metal sixty miles.

His feet at their fleetest will carry him along the ground at close to twenty miles an hour. A racing motor will carry him at two hundred miles an hour, and an airplane, three hundred and thirteen (at last accounts). He can swim about one-thirtieth as fast as a speed boat can take him through the water. He can jump at the best seven yards, but in a glider he can take a jump which covers many miles and lasts all day. In a diver's helmet he can breathe comfortably at the bottom of the sea; in a gas mask he can breathe in a volcano; and if he dies, a pulmotor may bring him back to life.

The peasant in his fields is six feet tall. But this man has swelled into a colossus, straddling continents. With his machines, he sees and hears and lifts and runs as no living organism ever dreamed of doing. He stands enormous, fantastic and alone; outside the laws of living organisms, a control switch in his hand. Power unlimited; sensitiveness unbounded. But one would take no peasant from his village in the certainty of making him happier in New York.

Whether machines for all their power are worth the human price which has been paid for them is still, for the philosophers, an open question. They turn with some reluctance from their considerations of infinity, the absolute, and the soul, but more and more the machine is beginning to intrigue them.

Indictments of the machine

One of the gloomiest of all tells us how an intrepid traveller left the last outposts of civilization, passed in turn a high range of mountains, a frightful gulf, a rushing river, another crest where great monolithic gods leered down upon him, and so came into a broad fertile country. His initial encounter with the inhabitants was friendly. But no sooner did he take out his watch, than he was arrested and put on trial for his life. The reason was finally made clear to him. He had been caught red-handed with a piece of machinery!

These people of Erewhon were a fair-haired, vigorous, contriving race extraordinarily like the Anglo-Saxon, who had independently invented first tool-machines and finally engines. As the centuries passed, the machines began to take on a tempo of their own—a process of growth, selection and hereditary function, which was, to all intents and purposes, biological. Machines, in effect, begat machines, and proceeded to swarm and herd and feed according to laws of their own. The human beings who had nursed them so tenderly awoke to find themselves with a new race of wild and dangerous animals all about them.

So after a stormy period of factional strife between the pro-machine and anti-machine parties, they finally destroyed every articulated crank and wheel and cylinder, sparing only the simplest tools for agriculture and handicraft. A few models were kept under lock and key in the museums, to serve as a horrible warning to future generations, but any attempt to resurrect or reinvent was punished with the full majesty of the state.

Our hero was not hanged but his watch was put in the museum, and he himself under strict observation. His further adventures, astonishing as they were, need not detain us here. The reader may discover or rediscover them in Samuel Butler's *Erewhon,* one of the world's great commentaries on modern civilization.

Suppose, however, that the pro-machine party had triumphed. Mr. E. M. Forster, doubtless inspired by

Butler, has developed this alternative in his own particularly penetrating style. In *The Machine Stops,* he traces the evolution of mechanization to the bitter end. For those of us who love life, it is not a pretty picture. For those who love their davenports and shaded lights and radios, there is something to be said for it.

> Imagine, if you can, a small room, hexagonal in shape, like the cell of a bee. It is lighted neither by window nor by lamp, yet it is filled with a soft radiance. There are no apertures for ventilation, yet the air is fresh. There are no musical instruments, and yet the room is throbbing with melodious sounds. An armchair is in the center, by its side a reading-desk. In the armchair sits a woman, about five feet high, with a face as white as a fungus. It is to her that the room belongs. . . . There are buttons and switches everywhere—buttons to call for food, for music, for clothing. There is the hot-bath button, by pressure of which a basin of marble rises out of the floor, filled to the brim with a warm deodorized liquid. There is the button that produces literature. And there are, of course, the buttons by which she communicates with her friends. The room, though it contains nothing, is in touch with all that she cares for in the world. . . . By her side, on the little reading desk, is a survival from the ages of litter—one book. This is the Book of the Machine. If she is hot or cold or dyspeptic or at loss for a word, she goes to the Book, and it tells her which button to press. . . .

All effort has been banished from this world. Mankind lives in perfectly ventilated, lighted, heated, perfectly comfortable cubicles far below the surface of the planet. The sun, the outside air, are anathema, and the Machine has replaced God. But gradually this Nirvana saps the vitality of those whose duty it is to inspect and repair the vast internal mechanism, the subterranean power stations which pump ease and comfort to all the world. They lose their formulas; the basic technology slowly dies and is forgotten. One day the lights go out, and when they come again, their brilliance is dimmed. The ventilating fans begin to creak, the music weakens, the synthetic food is not what it used to be. With Book in hand, the people pray, but it is oil the god needs. Finally, horribly, the Machine stops, and in a few gasping moments, life has ceased for the mass of mankind.

If these two prophecies, despite the merit of their celebrated authors, are held to be over-fanciful, let us listen for a minute to that solid sociologist, Mr. Austin Freeman. His *Social Decay and Regeneration,* endorsed by Havelock Ellis, is a compendium of contemporary facts; seldom leaving the confines of the world in which we live. Of all indictments of the machine so far promulgated, this is the most authoritative, complete and devastating. His thesis runs:

Before the advent of mechanical power, handicraft met demand as it arose. Shoes, furniture, clothing, pottery, hardware, were made for the individual. Then came James Watt and his steam engine. "The machine proceeded to develop in accord with its own laws regardless of the needs and conveniences of man. It continually increased its efficiency of rapid production with corresponding decrease of efficiency in elasticity and adaptability, which were not its mechanical functions. Very soon it had supplied the original demand and ousted the craftsman. But still production continues to increase, not in response to any demand, but under the compulsions of mechanical evolution. . . ." The relations of supply and demand have become inverted. Under the régime of hand production the problem was to supply consumers with commodities. The problem now is to supply commodities with consumers.

As machinery becomes more automatic—and that is the law of its development—the situation grows worse. Man without a working hand becomes, in the opinion of Mr. Freeman, a different and a lower organism. He loses independence and self-reliance; he is readily subjected to regimentation and discipline. His sense of personal liberty is aborted; his sensibilities blunted and debased. His only standards are for "qualities which are aesthetically bad but mechanically unavoidable." He becomes a watcher and listener, rather than a creator—a second-hand man.

Engines have devastated natural resources, destroyed natural beauty, created huge cities adjusted to the needs of themselves but totally unadjusted to the human beings, who, alas, must live beside them. Before mechanization, man seldom cluttered up his environment; often he made it more charming. Two centuries ago, one village could live without help from another; today if the supply of nitrates or sulphuric acid or petroleum were suddenly shut off, millions of people would presently be starving.

"The accumulation of technical knowledge has not been accompanied by a proportionate increase in intelligence. The whole history of the development of the power machine is one long record of perverse stupidity. . . . And finally by its reactions on the activities of war, it constitutes an agent for the wholesale physical destruction of man and his works. It is thus strictly analogous to those anti-bodies by which the existence of aggregates of the lower organisms is brought to an end. Like the anti-bodies it tends to convert an originally favourable environment into one so unfavourable as to be ultimately incompatible with the continued existence of the aggregate."

Mr. Freeman is more specific but hardly as weighty as the learned Dr. Spengler, who prophesies a time when man will "blot the machine from his memory and his environment, and create about himself a wholly new world, in which nothing of this Devil's technique is left." Here is the earnest group, which might be termed for want of a better phrase the Frankenstein chorus (in their dismay they sometimes mix Dr. Frankenstein with his monster) of which the Rev. Henry P. Frost is a typical exponent: "In this age of the machine, the shadow of the Frankenstein monster that we have made falls with sinister menace across the upward-reaching pathway of the race. We are all classified, standardized, regimented; while our human life and individuality are stifled and dwarfed." Professor Soddy warns us that if human ideals are not adjusted to the growth of science, and that quickly, he cannot be responsible for the outcome. Professor Haldane, with his usual charming originality, will have nothing to do with the Frankenstein chorus, but trots out for our inspection a Demogorgon—"Has mankind released from the womb of matter a Demogorgon which is already beginning to turn against him and may at any moment hurl him into the bottomless void?" Professor Russell thinks well of science on the whole, but has no faith in those who control the mechanical structure—their purposes "are in the main evil." Mr. Philip Gibbs allows us only the difficult choice between killing all scientists, and completely reforming man's moral and intellectual nature. Mr. Disraeli says that we have mistaken comfort for civilization, while Mr. H. G. Wells sees only "a race between education and catastrophe."

The brave battalion

After these prophets of doom, it hardly appears worthwhile to switch on the electric light and continue the analysis. Patagonia or prussic acid seem the only alternatives. But cooled by a whirling fan, I take heart to turn over my notes. And as I read, lo! down the street comes marching a thunderous brass band, dressed in the bravest of scarlet and gold, with Henry Ford at its head tossing a great baton into the air, and immediately behind him, Mr. Charles A. Beard, beating with all his might upon a huge bass drum. As he marches, Mr. Ford is shouting:

> The way to liberty, the way to equality of opportunity lies through power; the machine is only an incident. The function of the machine is to liberate man from brute burdens and release his energies to the building of his intellectual and spiritual powers for conquests in the fields of thought and higher action. Machinery is accomplishing in the world what man has failed to do by preaching, propaganda, or the written word—ushering in the United States of the World!

Mr. Beard assures us that a decline in Western civilization is unthinkable. Technology is not declining, literature is not declining, architecture and design are steadily improving; in every direction there is creative effort and vitality. Technical knowledge is not in the hands of one small group but widely diffused. If Europe and America were destroyed, Japan already possesses the formulas to rebuild machine culture in toto. We are thus different from Rome, Greece, Egypt and other agricultural civilizations, which eventually decayed. "Tested by the mildness of its laws, by its institutions of care and benevolence, by its death rate (that tell-tale measurement of human welfare), by its standards of life, and by every conceivable measure of human values, machine civilization, even in its present primitive stage, need fear no comparison with any other order on the score of general wellbeing."

Mr. Albert Parson Sachs views the new automatic power house of the New York Edison Company with tears of joy in his eyes.

> Man will achieve his greatest goal, universal leisure, through the building of better and more efficient machines. A later Samuel Butler will write a new *Erewhon* in which the Erewhonians will marvel that there ever was a time that humans thought that the race could be benefited by the destruction of machinery. Steel and copper, rubber and petroleum, coal and limestone, air and water ingeniously used by our scientists and engineers, are making a better and happier world.

Mr. Gerald Stanley Lee goes so far as to say, "It is in machinery that we seek for poetry and for beauty and for the Infinite. . . . Those persons who still fail to see this are blind, even already dead; they do not belong to our time."

Mr. Henry Hubbard, the Secretary of the Bureau of Standards, micrometer in hand, bids us remember: "Everywhere measurement is busy creating the tomorrow of our dreams. Man's miracles multiply, break the chains of time, place and circumstance, to give him vast degrees of freedom and new and limitless powers. Little wonder that Emerson, facing the new age of science, declared, 'I have never known a man as rich as all men ought to be'."

And Mr. Will Durant, student of philosophers, brings up the rear of the battalion with the refrain: "Everywhere the wonder of invention goes; striking the shackles from a hundred men at each step, making mechanical power cheaper than the humblest brawn, compelling men to be only the intellectual factor in the walk of life."

The fence rail

Meanwhile Mr. John Dewey and Mr. Harry Elmer Barnes sit side by side upon a high fence by the roadside; the mountains of Erewhon behind them, the scarlet battalion in front; long straws between their teeth. "I don't know," says Mr. Barnes, removing his straw. "Machines, now . . . either the greatest boon to humanity thus far achieved, or a Frankenstein monster ultimately destined to confuse and finally destroy his baffled creator."

"Yes," says Mr. Dewey, "one cannot be sure. If we look at the overt and outer phenomena of American life, the public and official side, we note hardness, tightness, a clamping down, regimentation and standardization. But if we look at the inner activities of individuals and groups, we note an immense vitality that is stimulating to the point of inspiration. Our civilization is like a Ford, mechanically good, standardized, yet capable of great mobility; ready to run on any road, restless, aimless, but vital and moving."

Presently Mr. W. F. Ogburn climbs up beside them. He doubts if there has been any change in the biological structure of man since the last ice age. Meanwhile there have been enormous cultural changes introduced over a relatively small period of time by the machine.

Does this prove that we were happier—because more normal—in the Stone Age, and less happy—because more artificial—now? Not necessarily. The stresses and strains of the Stone Age were considerable; there were, on the whole, more things to be afraid of. The modern factory worker, however, may be using only one set of muscles, where the caveman used all of his. It has been demonstrated that inadequate use of the whole muscle structure is bad for the organism. But alas, "there are no comparative censuses of the repression of instincts in primitive culture and in modern culture." We do know that man is a marvellously adaptable animal. He dropped the bow and arrow for the plow—revolutionizing his whole way of living; why should he not drop the plow for the tractor?

These philosophers of ecstasy, of gloom, and of the fence rail, could be endlessly multiplied—with total adherents probably in the order named. All are entitled to their views and many defend them with acumen and erudition. With the possible exception of Mr. Freeman, however, the exhibits given, indeed all the exhibits I have ever seen, are in summary form. We are told clearly enough what the philosopher thinks, but not why he thinks it. The underlying facts upon which the conclusions are based either do not come into the picture at all, or come only in the form of all too few examples. Before throwing in my lot with any of the parties—and I have been strongly tempted by the exponents of all three—I want to know more about the basic structure.

Precisely what is a machine? How does it differ from a tool; what are its laws? How many machines are there; how often do we encounter them directly and indirectly? Is this contact growing, and in what direction? How did the Machine Age start; why did it start; what are its main lines of development since James Watt? What does mass production really mean? Is anybody controlling the process or is it running wild in an orbit of its own? Is its destructive power in warfare as catastrophic as the Jeremiahs believe? Is it really making a new slave in the factory worker; and if so, is he a lowlier being than the galley slave of Greece? How many of these alleged robots is it making?

Are machines prolonging the average life span only to raise the percentage of invalids and neurotics? What are they actually doing to craftsmanship, skill, quality of output, art, architecture and recreation? Is social intelligence on the decline? Is social standardization a fact, and if so, is it any worse than the standard taboos and mores of other cultures, and of primitive peoples? Is it worse to be a Babbitt than a member of an Indian caste? How much justice is there in the claim that the sublime spiritual values of the East are crucified by the materialism of the West? Is the use of the hand actually declining, and if so, what of it? What is the limit, if any, to biological adaptation to the machine?

No complete answer to any of these questions is readily available, and for some the conflicting factors are too intertwined ever to be unravelled. But I believe it possible to make a beginning toward a better understanding of the machine, by telling what it is, what it does, and enumerating one by one all the major effects of its activity which can be isolated. I can promise in advance that many are capable of at least relative isolation.

One grows weary of wholesale denunciation and wholesale praise; while the fence rail has never been an over-comfortable resting place. This book is an unofficial survey of little explored regions. If you care to join a sort of a statistical Don Quixote, I shall be honoured with your company, but I warn you the topography is rough, the roads uncertain, and all too frequently unmarked. The clearest path is in technology, and here we had better start.

CHAPTER II

THE ANATOMY OF MACHINERY

In the previous chapter we talked freely about machines and their effects, assuming that the reader knew a machine when he saw one. Perhaps he does, but the author, alas, does not. Is a microscope a machine, or a stage coach, or a fountain pen, a safety razor, a piano, a cigar lighter? In Scotland, a wheeled wagon is still called a machine, and in England a little closet mounted upon a pair of wheels is known as a bathing machine. In these circumstances, perhaps the ancient joke was not so funny after all: "Come away from that wheelbarrow; what do you know about machinery?" Indeed, the word itself is derived from *man kina,* which means power applied to a cylinder of wood.

The learned professors have been at considerable pains in their attempts to make a distinction between tools and implements on the one hand, and machinery on the other. Nor have they arrived much of anywhere.

The one is continually shading into the other. Here is an ordinary shovel used by a day labourer in a ditch; here is the same shovel with a somewhat thicker handle, containing a pneumatic attachment which is said to improve its digging power; here is a very much larger shovel with curved ends and steel teeth, hitched to an arm that is hitched to a steam engine, which can gobble up a cartload of dirt at one mouthful. Where does the tool stop and the machine begin? A grindstone is widely held to be a primitive tool; a turret lathe is widely held to be a machine. Both spin around. What is the essential difference? The employment of non-human power, steam, oil, gas, has been defined as the difference. Well and good. Then everything worked by human hands and legs is a tool only, and bicycles, typewriters, adding machines, sewing machines, foot lathes, clocks, hand-pumps—are not machines. Which is absurd. And what is one to do with treadmills for grinding corn, whose motive power is said by some to be the donkey, and by some the carrot in front of his nose?

Certain anthropologists hold that man, having discovered tools, ceased to evolve biologically. Animals, never having discovered them, continue to fashion drills out of their beaks, oars out of their hind feet, wings out of their forefeet, suits of armour out of their hides, levers out of their horns, saws out of their teeth. Whether this be true or not, all authorities agree that man is *the* tool-using animal. It sets him off from the rest of the animal kingdom as drastically as does speech. If tools are machines, machinery has been in our inheritance for at least one hundred thousand years, and if this school of anthropology is correct, we have become biologically adapted to the tool-machine.

The Encyclopedia Britannica defines a machine as "any device or apparatus for the application or modification of force to a specific purpose." I would go even farther and define it as any non-living contrivance to extend or modify the power of the body, or to refine the perception of the senses. Its commonest function is to transform random energy into disciplined energy. It thus includes tools of all kinds, and mechanisms for more careful recording and measurement—the transit for instance, or the telephone receiver.[1] There are devices for stepping down power as well as for stepping it up. A loud speaker can be adjusted either to bellow or to whisper.

The concern of the Machine Age is not with nice distinctions in terminology, but with those particular sorts of tool-machines which are doing new and unprecedented things to modern civilization; things which no earlier civilization ever experienced; which are changing timeless concepts and habits, engendering unheard-of behaviour patterns. And from this it follows that in the last analysis it is not so much machines which we face, as it is *power.* Says Henry Ford:

---

[1] One good engineer objects to my including instruments of precision with machines. But I shall continue to do so for two reasons. They are mechanisms involving levers, screws, ratchets; and they are of the utmost importance, as we shall see later, in the development of the Machine Age.

> The source of material civilization is developed power. One way to use the power is through the machine, and just as we often think of the automobile as a thing in itself instead of as a way of using power, so also do we think of the machine as something in itself instead of as a method of making power effective. We speak of the "machine age." What we are entering is the power age.

The only amendment that I would propose is that we have been in the Power Age for several generations, and officially entered it with the steam engine of James Watt, along about 1775.[1] When we learned to yoke our tools (or our machines, as you like); our hand looms, our primitive blast furnaces, our saw mills, our potters' wheels, our wheeled wagons, our boats, to a moving crank shaft, the Power Age was born.

The total man and animal power of North America and Western Europe probably does not exceed the equivalent of sixty million horsepower, while the total horsepower capable of generation in the engines of the two continents is well over a billion. We have stepped up power at least fifteen-fold in the last century.

In any given power mechanism, there are, as a rule, three major parts. The engine, called by engineers the "prime mover" which delivers power to a shaft; the end tool which does the required work—pounding, digging, cutting, weaving, pumping, traction wheel turning; and the devices which yoke the shaft to the tool—the belts, gears and levers. Thus in an automobile we have (1) the engine and crank shaft, (2) the transmission mechanism, and (3) the tool, in this case the rear wheels. What the Power Age has done is enormously to increase the effectiveness of prime movers, which before its coming were limited to windmills and primitive water wheels. With power available, a flood of new tools and variations on old tools have been invented; meanwhile, the utmost ingenuity has been expended upon the really beautiful devices which link the prime mover, or engine, to the working tool.

---

[1] Mr. F. G. Tryon goes even further and proposes the Age of Energy, in that "the industrial revolution was no less a sudden advance in the art of applying heat than in the art of applying mechanical motion." Energy covers heat as well as power.

Engines

In Chaucer's time "engine" in English meant natural talent: "A man hath sapiences thre, Memorie, engin and intellect also." Obviously it was the "engin" which furnished the drive to his personality, and so the evolution to modern usage is a reasonably logical one. The engine is the driving force of the mechanism. As we shall see in the next chapter, the ancients used the word fairly loosely to include a great variety of mechanisms and devices. A catapult was an engine of war, and even a bone digester was described by Papin as an engine.[1] As an antidote to our very wide definition of machinery, it may be well to draw the line more tightly around engine—particularly as it has rather definite limitations under modern usage. An engine, according to E. N. Andrade, "is any machine made for the purpose of turning some natural source of energy into work." In other words, an engine is a mechanism for converting raw natural energy—the heat of coal or wood or oil, the burning of certain chemical combinations, the force of the wind, of the tides, of falling water—into the motion of a bar which swings to and fro, or goes round and round. An engine, therefore, deals exclusively with non-living forces. When a man or an animal furnishes the power, the contrivance ceases to be an engine. Only the wild powers of nature are caught and tamed by engines.

There are many devices which furnish power to tools that sometimes seem to increase the human energy put into them. In reality they never deliver as much energy as they receive, because of friction, but they transform the thrust or blow into a specific channel and thus often appear magically effective. An arrow, hurtling from a bow, goes with the energy of the arm and no more. A sling shot, a blow pipe, a jack under a motor car, never create energy of their own, but only take and deliver to a focal point the energy the man puts in.

---

[1] "I took beef bones, these being put into a little glass pot, with water, I included in the engine. . . . Having prest the fire, I found a very good jelly in my pot, and having seasoned it with sugar and juice of lemon, I did eat it with much pleasure, and found it as stomachical as if it had been jelly of hartshorn."

A true engine, on the other hand, while it does not, in the strictly scientific sense, create energy, makes it available without equivalent effort on the part of any living being. The man puts nothing directly in, and lo! thousands of horsepower come rushing out. The whole business comes perilously close to getting something for nothing. It is not too much to say that the Power Age is built on this lop-sided equation. It is a formula, furthermore, likely to encourage a race of prodigals.

The pragmatic effect, so far as man is concerned, is that he secures unlimited power without the sweat of his brow. That is, without a proportionate amount of sweat. The power is not altogether free, because he has to pay in the mental exertion of inventors, in the building of engines, in the furnishing of materials and fuel for them, in the stoking of their furnaces, and in other ways. But in the august region beyond man's efforts, the celestial books are balanced to the penny. Under the law of the conservation of energy, nothing comes out of an engine which is not first put in—with friction charging its eternal commission. Only here not man, but nature, puts it in.

Furthermore, under the first law of thermodynamics a given amount of heat is transformable into a given amount of energy, always at the same rate, and vice versa. While under the second law of thermodynamics there must always be a difference in temperature in the engine if heat is to be turned into work, and the amount of work obtained depends upon the extent of this temperature difference. All *heat* engines are based on these two laws, and by far the greater amount of the work energy liberated in the world today is generated by heat engines; those which run a temperature on the one side, and set a bar rocking or rotating, on the other.

The basic engines may be listed as follows:

HEAT ENGINES

Steam and vapour

Suction steam engine. Sucks and blows only. No moving parts. Not widely used.

Atmospheric engine. Uses steam to create vacuum in cylinder, but not to push the piston. Extinct.

True steam engine. Reciprocating type. Invented by Watt. Steam pushes piston.

Steam turbine. No cylinder or piston. Steam pushes against blades and revolves whole mechanism. (Gas turbines are also being experimented with.)

Mercury vapour engine. Built on same principle as steam engine but uses mercury vapour instead of water vapour. (Mercury vapour turbines may have a great future.)

Hot air engine. Uses hot air instead of steam. Extinct, except as toy.

Cold air engine. Creates temperature differences at lower level, but on same principle. Extinct.

Liquid air engine. Still lower temperatures. Extinct.

Internal combustion

Gas or gasoline engine. No boiler. "Fire in cylinder." Spark explodes gas mixture to push piston. Enormous use.

Diesel engine. Explodes fuel oil by heat of compression. No spark. Widely used.

Gun powder engine. Invented by Huygens, 1673. Piston pushed by gun-powder charge. Toy only.

The gun as an engine. A sort of "one-stroke internal combustion engine, which throws away its piston at each stroke." (Big Bertha used to throw her piston about 60 miles.)

Other heat

Rocket engine. Works on "kick back" principle. Long used in fireworks. (May have a future.)

NON-HEAT ENGINES

Windmill. Not widely used industrially.

Rotor engine. Special form of wind engine. Experimental stage.

Water wheel. Old wheel has given place to modern turbine. Widely used, particularly for operating dynamos.

Hydraulic ram. Uses energy of falling water in cylinder rather than turbine form. Not in great demand.

All the engines listed above, with the exception of the suction and the rocket types, deliver energy to a bar. When the bar works back and forth, the engine is known as reciprocating; and when it turns round and round, it is called a turbine, or rotary engine. An automobile has a reciprocating engine and so has a locomotive. In the latter you can see the steel bar coming out of the cylinder, and by means of the connecting rods and crank turning the driving wheels. Turbines produce rotary motion by themselves revolving. A windmill is a sort of turbine; the wind acts on a set of sails, or curved blades, and blows the mechanism around. Similarly one can make a wind, indeed a super-hurricane, with rushing steam, and blow a set of blades around the great steel bottle of a steam turbine. With a different shape of blade, and a wind of rushing water, we have a water turbine. (The hydraulic turbines at Niagara Falls do the work of 1,633,000 men.)

Of all heat engines, the Diesel is most efficient, in that it can turn the most heat into work. It is still, however, appreciably short of perfection, as the following ratios show:

Diesel engine—33 per cent efficient.
Stationary gas engine—30 per cent.
Steam turbine—28 per cent.
Best reciprocating steam engine—22 per cent.
Average stationary steam engine—17 per cent.
Good locomotive—5 per cent. "The other 95 per cent goes ultimately to warm up the country-side."

Meanwhile a good water turbine is far more efficient than any heat engine, turning as much as ninety per cent of the power of the falling water into tangible work.

The great engines

Some engines have served their turn and passed to honourable burial, like Newcomen's atmospheric monster. Others have never gone beyond the toy or physical laboratory stage. Others, like the rotor, and mercury vapour turbine, look promising but have yet to prove their final value. This leaves us with just five great prime movers which have made, or are making, the Power Age.

The reciprocating steam engine
The steam turbine
The water turbine
The gasoline engine
The Diesel engine

Of all the kilowatts of power let loose in the world today, it is safe to say that these five engines account for ninety-five per cent. They furnish the drive for the tools, the mechanisms, the devices, that make our Western world what it is. Upon their heads fall the problems which beset us. Four of them are heat engines, and one is turned by falling water. The heat engines are made hot by two main sorts of fuel—coal and oil. The coal heat must be turned into steam before the engine will work, but the oil heat may be generated, in the form of an explosion, in the cylinder itself. Automobile engines, in the aggregate, are the greatest prime movers in America. They are capable of generating more power than all other prime movers combined.

Secondary movers

In addition to the engines listed, there is a further enormously important class that might be termed secondary movers, of which the electric motor is the outstanding example. A motor generates no power, it simply takes electric current which a prime mover has generated through a dynamo—perhaps a thousand miles away—and turns it into work. Its great virtue is its mobility; it can be set up anywhere, provided a wire leads back to the dynamo which the prime mover is turning. Before long we may be able to dispense with the wire, and send current economically by radio beam energy. Motors are used increasingly to run factory machines, thus cutting down noise, smoke, a tangle of belts, mechanical complexities, and usually expense. The motor permits the transfer of factories, of whole industries, from the smoky lowland districts where prime movers chiefly make their dens, to regions as remote and as beautiful as you please. It marks one of the most important turns, so far as the effect on human living is concerned, which the industrial revolution has so far taken.

There is one more type of engine which is like the motor in that it stands one step beyond the prime mover, but unlike it, its function is to produce not work but cold. Over 150 industries and trades at the present time need refrigeration, including cold storage for food, for furs, for battleship magazines. There is even a new process for drilling wells in swampy places by first freezing the ground. The mechanical refrigerator, in these industries or in the home, works on the same laws of thermodynamics as the heat engine, but it stands so to speak on its head, turning work into minus heat.

Indeed, the power of a prime mover is capable of all sorts of transformations. It may be turned into motion, into work, into cold, heat, sound, light, vibration, pressure.

Future engines

Are we likely to see any new sorts of engines in the immediate future? Probably not. Mr. Andrade notes nothing portentous on the horizon, nor do other scientists who know their thermodynamics. They do not deny the possibility, but they leave the amazing new discoveries to the Sunday supplements—where they mostly stay. About the most valuable new engine imaginable would be one which could economically turn a large portion of the heat energy of coal directly into electricity, thus removing the boiler, the cylinder and the dynamo from the picture altogether. Such a short circuit is not beyond the bounds of hope.

In an ounce of any given material there is locked up several million horsepower of atomic energy, so sheltered that none of our ordinary agents—great heat or tremendous pressure—affect it in the slightest. Some prophets see all other engines cold and dead before the engine (it will have to be a new type) which turns atomic energy into work. But Robert A. Millikan, one of America's leading physicists, is pessimistic on this score. "The energy available through the disintegration of radioactive or any other atoms may perhaps be

C487
Philura Gould Baldwin
Memorial Library

sufficient to keep the corner peanut and popcorn man going in our large towns for a long time to come, but that is all."

There are other projects, perhaps more immediately realizable, which look toward the development of natural forces without entailing a basically new type of engine. Mr. J. B. S. Haldane looks for a tremendous development of the windmill. He would run great batteries of windmills to furnish power for decomposing certain chemical mixtures, which in turn could be used to generate electricity when needed; in brief, a gigantic storage battery device. The turbine, which gives us "white coal" from falling water, is already very efficient, but some modification of it may be developed which will furnish "blue coal," from the tides or from the motion of the waves. Blue coal requires an immense capital outlay, but it can undoubtedly be secured when we need the additional power badly enough. It is a matter of great dams and floats rather than engine principles. M. Georges Claude, the inventor of liquid air, proposes to use the difference in temperature between the surface and the depths of the ocean to operate great heat engines, and is even now setting up an experimental plant. Lastly, it is not inconceivable that there may be a brisk development of the rocket engine principle in the next few years. Speeds of over 100 miles an hour have already been obtained by rocket automobiles, while at least one inventor is at work on a sky-craft with which he courageously proposes to explode himself to the moon.

12175

There may be no oil left in the crust of the planet in another 50 years, in workable quantities; in 500 years or less the coal supply for certain grades may be exhausted. Falling water runs on for geological periods, but there is hardly enough of it available in all the world's streams and rivers to produce as much horsepower as the world already uses. With the atomic engine apparently out of the picture, the turn of the tides, the sea bottoms, the winds and the waves may come.

Machine functions

The number of engines is limited and it is possible to sketch the broad outlines of their anatomy. To sketch even the outline of the devices for delivering the power of prime movers to working tools would take a volume, while to outline the anatomy of the working tools themselves would take a library. Another library would have to be devoted to mechanisms worked by human and animal power. To reduce this bewildering array to simple and comprehensive classification,—1,699,145 mechanical patents have already been taken out in the United States—lies quite beyond my power, and, I suspect, beyond anybody's power.

To remind the reader that all machines are based on six fundamental principles—the lever, the wheel, the pulley, the wedge, the screw, the inclined plane—sounds clarifying, but it is not really very helpful. Two methods of possible simplification remain. The more important functions of the working tool can be listed. Secondly, a list can be made of the common types of machines; those with which we most frequently come into direct contact. In Chapter VI such a list is prepared in connection with an attempt to show the mass impact of machinery at the present time. A functional classification follows. It is far from complete, but the main elements are probably included. A specific machine is given with each function by way of illustration.

PRIMARY MACHINE FUNCTIONS

Body movements

Pounding—steam hammer
Crushing—rock crusher
Blowing—electric fan
Sucking—vacuum cleaner
Digging—gang plow
Pushing—hydraulic ram
Pulling—locomotive
Dancing—merry-go-round
Lifting—derrick
Picking—cotton gin
Hurling—gun
Scraping—potato peeler
Shaping—power lathe
Spreading—seeder
Twisting—lathe drill
Weaving (matting)—power loom
Swimming—ferry boat
Carrying—motor truck

Body plus simple tool movements

Cutting—guillotine
Chipping—ingot machine
Sawing—band saw
Splitting—rock drill
Grinding—stone plane
Boring—diamond drill
Drawing—kodak
Spraying—fire engine
Sewing—sewing machine
Writing—automatic typewriter

PRIMARY MACHINE FUNCTIONS—*Continued*

Sensory functions

Seeing—telescope
Hearing—telephone
Talking—radio
Singing—piano
Shouting—claxon horn
Calculating—adding machine
Time measuring—watch
Space measuring—transit
Weight measuring—scales
Temperature measuring—thermometer
Pressure measuring—barometer
Direction measuring — compass
Sound measuring—Dr. Free's machine

Miscellaneous

Detonating—torpedo
Flying—airplane
Light making—flashlight
Heat making—electric furnace
Cold making — refrigerating engine
Pressure making—air pump

If this list be sufficiently comprehensive, it is clear that the bulk of machine work is simply to extend the power of human muscles, or refine the perception of the human senses. With a pump we can draw up more water than we can with our hands; with a gun we can throw farther than we can with our arms, with a calculator we can compute faster than we can in our heads. Most musical instruments are machines, and their function is to complement, or act as substitutes for, the human voice. If one cannot sing, he can express himself upon a clarinet—or even, Heaven help us, upon a saxophone. The things which, reduced to simplest terms, machines can do better than the body are many; the things which machines can do that the body cannot do, even with the aid of simple tools, are few—of which flying is perhaps the outstanding example.

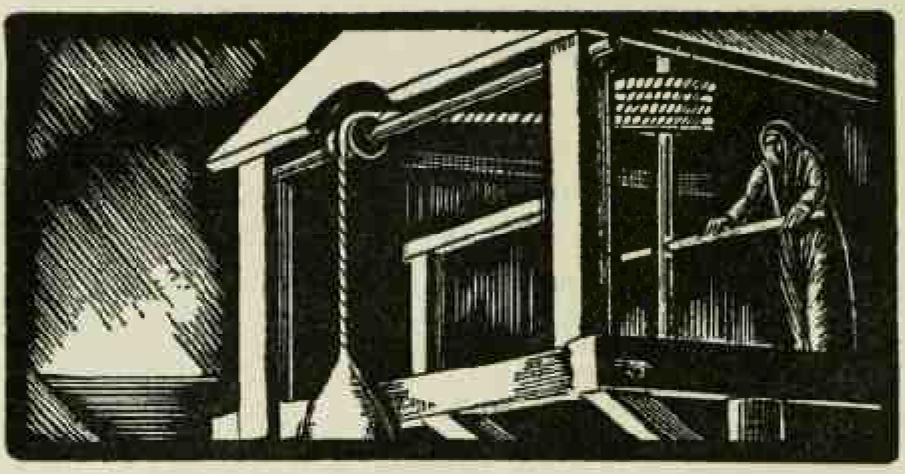
It is interesting that no machines have yet been devised to measure smell or taste, though seeing, hearing, and touching all have their mechanical refinements. Alexander Graham Bell called for a smell-ometer, but nobody has yet produced one. It would be useful in the diagnosis of diseases—many of which have their peculiar odour; in the perfume industry; in killing insect pests by finding out what smell attracts them. In brief, our noses are no better than Homer's, and quite possibly not so good. Meanwhile the human taste buds are all we possess to grade the excellence of teas, coffees and tobaccos.

It is difficult to detect anything ominous in machines as classified above, while it is easy to detect much that is genuinely desirable. The extension of bodily movements and sense perceptions is obviously a good and helpful thing. It saves us much dull, hard work, it refines our senses, gives us the possibility of living more complete lives. Of course we can, as it were, stretch ourselves out too thin; live more intensively than biological adaptation permits. Or we can give to machines work that the body should do, if it is to function properly (Mr. Forster's contention). Or we can pervert our normal functioning through excessive machine-tending, and so turn a potential gain into an actual loss. We shall examine these possible perversions as we proceed, but certainly the functional classification makes it obvious that there is nothing innately evil in the kind of work which most machines are designed to do. The evil, if any, must come in the abuse of function. The gloomy prophets quoted earlier have concentrated their attention on abuses, found them widespread and grievous, and have cried out in horror, without stopping to analyze carefully just what it is that machines are supposed to do.

One night I visited the headquarters of a great broadcasting company in New York. In a somewhat rococo room, known as a studio, I saw a fourth-rate politician shouting cheap propaganda into a microphone; filling the room, and the outside air for hundreds of miles, with a flood of gaseous, empty platitudes. In another room, not thirty feet away, I saw intricate, beautiful mechanisms for controlling the broadcasting process. Here was a great wall lined with dials, switches, flashing signal lights, instruments and connections of the utmost delicacy, which patiently and uncomplainingly took the sound waves that crashed against the microphone, refined them—now softening, now amplifying—turned them into electrical energy, cast them into space, and followed them like a guardian angel, fighting with monstrous, elemental forces seeking to deflect or mar their passage through the ether. This, it seemed to me, was not a case of the machine failing man, but of man failing the machine.

One final thought detains us, before we leave the anatomy of engines and machines. It is probable that the Power Age would never have come to us, even as it never came to Egypt or to Greece, had we not adopted, some hundreds of years ago, Arabic numerals and particularly the Arabic cipher. The decimal system with its zero enormously simplified calculations. (Try to multiply CCCXLVIII by MDCXIX.) The science of measurement must have remained in its infancy without the zero. And the science of measurement is the lifeblood of engines and of all complicated mechanisms. Intricate mathematical calculations are first necessary in working out the principles of thermodynamics, of the behaviour of fluids, of electricity, of all the pure science upon which complicated machines, and particularly engines, rest. Secondly, in the construction of those engines, exact measurement is cardinal. It is utterly impossible to make a vacuum tube by trial and error handicraft. A skyscraper is a towering mass of calculations, worked out on paper before one stone is laid upon another. In the manufacture of an automobile there are 40,000 separate measurements to be taken in constructing the original model. When speculation as to the behaviour of natural forces moved out of the armchair and into the laboratory, notebook in hand, modern science began.

It is not perhaps too much to say that a billion horsepower rest on nothingness, on zero. . . . This gives the armchair philosophers an unlimited opportunity, and they are welcome to it. We have other work in hand.



CHAPTER III

MACHINES OF THE ANCIENTS

ABOUT 5,000 years ago, an Egyptian gentleman by the name of Ptah-hotep wrote out a series of instructions for his sons. Fortunately these instructions, as well as dealing in matters of ethics, reviewed the material culture of Egypt at the time; and doubly fortunately, the stones upon which they were written have been preserved down the ages. They present us with an idea not only of the mechanical devices of the period, but of the astonishing cultural level made possible by the stability of food supply along the margins of the Nile.

The generic Egyptian of 3000 B.C., though unacquainted with iron, was an expert metallurgist in the less refractory metals. He could smelt them, draw them into wire, beat them into sheets, cast them into moulds, emboss, chase, engrave, inlay, and enamel them. He had invented the lathe and the potter's wheel and could glaze and enamel earthenware. He was an expert woodworker, joiner and carver. He was an admirable sculptor, draftsman and painter. He was, and is, the world's mightiest architect in stone. He made sea-going ships. He had devised the loom, and knew how to weave cotton to such a fineness that we can only distinguish it from silk by the microscope. His language was rich, and he engrossed it in the handsomest system of written characters ever produced. He made excellent paper, and upon it a beautiful literature was written. His numerous musical instruments included the harp, lute, viol, drum, sistrum, cithern, dulcimer, flute, and trumpet. He had a metal currency. His weapons were the sword, spear, bow and arrow, sling, and boomerang. He had invented most of the hand tools now in existence. He had domesticated the ox, sheep, goat, horse, camel, dog, cat, pig, and various birds. He was an expert farmer, and a skilled irrigation engineer. He fashioned some of the loveliest furniture which the world has ever seen, and cut and polished precious stones. He had worked out the rudiments of astronomy and mathematics. And now we find him passing on to his sons the ethical code of a gentleman.

In the light of these achievements why was the industrial revolution not born beside the Nile fifty centuries ago, rather than in the gloomy hills of Northern England, forty-eight centuries later? After canvassing all the available records, the only answer that I can find is that it was not born because it was not needed. With a vast supply of drafted peasants and slaves to do the most colossal tasks with the simplest tools, Egyptian gentlemen were content to let well enough alone, and devote themselves to the fine arts of life rather than to tinkering with engines. Exact measurement and the Arabic cipher were still unheard of, nor had any Roger Bacons, Leonardos, Newtons arisen to lay the basis for the laws of cylinders and pistons. But for all these pat answers, one still keeps wondering. . . .

The great Egyptian discoveries came with dramatic speed, within a century or two. Before that, inventors had produced at a leisurely rate, over more than 100,000 years, various useful but primitive contrivances. We have evidence of flint tools at least 125,000 years ago. The tools of prehistoric hunting cultures were chiefly the club, spear, knife, axe, bow and arrow. Primitive agriculture knew the plow, spade and sickle. With the first metal-working the early craftsmen invented the saw, shears, gimlet, tongs, plane, lathe, bellows, potter's wheel and loom.

The initial approach to our own notions of a proper machine was a log used as a roller to move heavy loads. As we have seen, the word itself connotes power applied to a cylinder of wood. The wheel and the wagon followed the roller. Wheels were first solid wooden discs which revolved with the axle; later came the fixed axle. The wheel is undoubtedly the most significant of all the basic tools upon which machines are constructed. A twirling stick was early in use to produce fire. Quicker action was developed with the bow and string. From this it was not a long leap to the drill. Refinements in method were worked out by the early Egyptians, Assyrians and Chinese, some here, some there; and by the mysterious channels of culture diffusion, finally implanted in each civilization.

A very early machine-tool using the principle of both the screw and the lever was an Egyptian crank drill invented in Ptah-hotep's century. It is a bar with a toothed drill at the bottom, a crank to turn it at the top, and circular side wings to steady it. It marked the beginning of the great period of Egyptian technology. In 3050 B.C., the first stone masonry had not been laid. Yet within one hundred and fifty years the grandest monument ever built by man was raised to stand immutable and eternal in the desert. It took 100,000 men twenty years to lift the monolithic blocks of the Great Pyramid by some combination of levers and planes. Labour might be cheap at a few handfuls of grain a day, but this did not solve the element of time. A Pharaoh of all men would like to see his tomb before he died. Why not a windlass or a crane to lift his blocks; why not a power beyond that of men to move them?

The great stones were quarried by drilling holes along the face of the ledge, inserting wooden pegs, wetting them, and so splintering the rock along the predestined line. Drills were copper tubes, and long copper stone saws were also used. A single stone for the Colossus of Rameses II was sixty feet high and weighed 887 tons. One has been found weighing 1,200 tons. The stones were slid down a runway to the Nile and there loaded upon rafts, buoyed up with inflated skins. The rafts were piloted, in some cases great distances, to the site of the temple or the pyramid. The stones were unloaded and placed upon a wooden sledge, running upon an especially constructed road of polished stone. Gangs of workers pulled the sledge by ropes—thirty-six men and a whip master to the rope, while for especially great stones, other men with levers and wedges toiled in the rear.

No one today knows exactly how the pyramids were built, or the precise methods for getting the great obelisks and colossi into place. We must rely on sculptured bas-reliefs—remembering that there is something of the poet in every sculptor. For the pyramids, engineering opinion is divided between levers, rocking-cradles and inclined planes, with the former method slightly in the lead. Zimmer believes that a whole series of weighted levers were placed on either side of a stone. A company of laborers pressed them down. Up came the stone. Then while it hung suspended, other workers feverishly piled earth underneath. With a new dirt foundation, the process could be repeated—theoretically to any height. (The top of the Great Pyramid is 450 feet above the Nile.) Once height is secured, the stone can be allowed to slide down a prepared plane to its appointed position in the structure. Obelisks were almost certainly erected by this method. When the proper height was reached, the earth was dug away at one end, and slowly the base of the vast stone sunk down to its waiting pedestal, the whole being steadied and guided by ropes.

Incredible as was the stone work, some authorities hold that the Egyptians and Mesopotamians were even better hydraulic engineers than they were structural. Both civilizations were based upon river systems: the Nile, and the Tigris and Euphrates. To produce the grain upon which life depended, these rivers had to forsake their ancient anarchy and submit to the control of man. When we consider how the Mississippi in 1928 defied all the engines of the industrial revolution and laid waste its valley, we can glimpse something of the task which these early engineers had upon their hands. Hands is precisely the word; all the treasuries of the Pharaohs could not produce a steam shovel. Not only had floods to be controlled, but millions of acres of farm lands had to be irrigated. For 100 days following April the first, the Nile was below the level of the fields. During this period it has been calculated that 1,600 tons of water per acre was needed to maintain fertility, and it had to be lifted from the river to a height varying from eighteen inches to thirty feet.

In raising water from the Nile to the fields, a real tool-machine was employed. The earliest was called a *shadoof,* and you may see its great-grandchildren in Egypt—and even in parts of Russia—today. It had three parts: a weighted beam, a bucket and a basin.

The bucket, which was attached to the beam, was dipped in the river, swung around and up, and its contents poured into the basin on the bank, from which troughs ran to the fields. If the bank was high, a second and a third shadoof lifted from one basin to another, for the working range of the device was only about eight feet. Where the current was swift, the Egyptians later developed and installed a real engine; possibly the first power device not to be worked by man or animal. An undershot water wheel with cups on its circumference turned in the stream, filling the cups, lifting and automatically emptying them into a trough. Here we have not only an engine, but an automatically operated one. It could clank away all night soaking the thirsty fields with nobody in attendance. Why did they not go farther? . . . Still later, an endless bucket chain was worked out for lifting water, the *tympanum,* driven by an ox.

Meanwhile Hu Shih tells us that "all the legendary kings of China were not priest-philosophers but inventors. Such, for example, were Svi-jen, the discoverer of fire, You-tsao, the first builder of houses, and Shen-nung, the first teacher of agriculture and medicine." Hand-minded men, tool users. Indeed, in tombs on the Nile, and the Euphrates, in the marshes of Scandinavia, in the rocks of Peru, all over the ancient world, the average grave is a store-house of mechanical implements. For every flute or precious ornament, we find scores of working tools.

The Greeks

Aristotle mentions the lever and balance-weight, the beam scale, tongs, wedges, crank and axle, roller, wheel and pulley, pulley block, potter's wheel, catapult, toothed wheel. The screw he knew nothing of; it came from Egypt about 300 B.C. Breasted claims that Greece also had her "industrial revolution," a century of phenomenal material advance. On examination, however, it turns out to be a commercial revolution. Trade expanded, money and credit came into use, butter-and-egg men elbowed nobles, household handicraft shops were expanded into factories employing slave labour, the price of armour and weapons fell sharply, enormous trireme battleships were constructed with three tiers of slave-manned oars. But with a population of only 5,000,000 freemen against 12,000,000 slaves, no startling new machines were needed, or invented. Van Loon lays down the law that "the amount of mechanical development will always be in inverse ratio to the number of slaves that happen to be at a country's disposal." (Which puts one in mind of Bertrand Russell's famous law that "the intensity of religious belief among sea-faring folk is inversely proportional to the size of their vessels.") And for proof he cites the far greater number of mechanical patents taken out in the United States in the first sixty years of the Nineteenth Century by citizens of the northern states, compared with those of the southern. Indeed Van Loon holds that by and large both the Greeks and

Romans were less inventive than the Egyptians, in that they relied even more heavily on slave labour. Egypt and Mesopotamia specialized in peasants, drafted for service between crops.

Says Xenophon: "The arts which men call vulgar are commonly decried with good reason. They utterly ruin the bodies of workers and managers alike, compelling men to lead sedentary lives, and huddle indoors, or spend the day before the fire. Then as men's bodies become enervated, so their souls grow sicklier. And these vulgar crafts involve complete absence of leisure, and hinder men from social and civic life; consequently men such as these are bad friends and indifferent defenders of their country." One fears that Xenophon would make but an indifferent week-end guest at Henry Ford's. Even Archimedes thought it degrading to put science to practical uses—but it is to be noted that his military engines kept the Romans out of Syracuse for three long years. The Greeks dabbled a little in pure science, but not until the great library at Alexandria reared its columns did they stoop to the development of engines and machines, and that was centuries after the days of Pericles. One small exception may be noted, embalmed in a phrase which is still current coin. When a dramatist had involved his plot beyond all human solution, an actor, attired as a god, was swung upon the stage by a crane. He divinely solved the riddle, and was known as *theos apo mechanes,* the god from the machine.

The Romans

The Romans on the whole did better. Their engineering particularly was far advanced. But they did nothing to controvert Van Loon's law. They developed no power engines, and made few significant improvements in tool-machines. The emperor Vespasian, eager as he was for public economy, when offered a mechanical device with which to cheapen construction work, bought the model and destroyed it. Pliny describes a rudimentary reaping-machine, driven by oxen, and used only on large level estates. It was a great, clumsy device, but the design remained unchanged for 300 years—from the First Century A.D., to the Fourth. The gulf between Detroit and Rome could hardly be better illustrated.

Before the dawn of history, grain was ground by pounding it between two stones. Then came a saucer hole in the lower stone, and an upper hand stone, round or pestle-shaped. To the Romans in 200 B.C. belongs the invention of the *quern,* or revolving millstone, which wrought a revolution in the art of milling. Here the nether millstone lies on the floor, circular in shape with a convex face. Over it fits the concave quern, or upper stone, of the same diameter, with a hole in its center through which a handful of grain may be poured. The quern is spun around by a handle on its outer edge, grinding the grain, which leaks out between the edges of the two stones. The Romans built querns as large as five feet in diameter. Sometimes they put the stones on a raft in the river, and turned them with power from an undershot water wheel. It is also recorded that the Romans had disappearing and revolving stages in their public theatres and certain "automatic marvels"—doubtless for the discomfiture of lions and Christian fathers—in the Colosseum.

To reinforce concrete, they used burnt tile. Their bridges, roads, aqueducts and harbour works were phenomenal—the more so because they were all constructed on trial and error, without quantitative analysis, and with only the crudest instruments. They had no notion of how to measure the flow of water through a pipe. An early tunnel in Palestine was designed to cover a distance of 1,100 feet. Being started at both ends and unsurveyed, it wandered around inside the hill, and finally covered 1,700 feet before the blind ends met. This is the more lamentable when it is remembered that the chief method of driving a tunnel was to split the rock by first making a roaring fire, and then dousing it with cold water.

Two "scientific" tests for water have come down to us, both supplied by Vetruvius:

> Look at people who drink it. If they are strongly formed, of fresh color, with sound legs and without blear eyes, the supply is of good quality.

And in respect to locating a water supply:

> One must lie down prostrate in the spot where he seeks and with his chin placed on the ground, the eye cannot rove upwards further than it ought and is confined to the place,

and where the vapors are seen rising from the place in the air, there dig, because these appearances are not seen in dry places.

After all, what need had the Romans of employing good brain power on invention? Wherever their legions marched, two sorts of captives were always brought home: fine women and skilled artisans.

Hero of Alexandria

In Hero we have a man whose only rival for sheer inventive genius is Leonardo. Watt based his engine on Newcomen's, but Hero designed the first heat engine literally single-handed. Great inventors receive, as a rule, far more credit than is due them; they stand almost without exception on lesser men's shoulders. But Hero, so far as we know, is one exception, and Leonardo another. Both were so far in advance of the art of iron-working, that their genius could not flower into many practical appliances. This is where Watt's great advantage lay. He could find a smith capable of fashioning an iron cylinder that would sustain a vacuum.

We know Hero chiefly from his *Pneumatica,* published in Alexandria in the First Century B.C. and translated into English about 1600. Its pages make clear that he understood the general behaviour of steam, the use of the cylinder and piston, the three-way cock, slide valves and valve clacks. He describes a heat engine which he built, and christened the "Aeolipile." It is a primitive reaction turbine taking the form of a hollow metal ball mounted on pivots. Steam enters the ball through one of the pivots and escapes through two bent pipes. The reaction of the escape revolves the ball, and makes a genuine prime mover of it. He describes various surveying instruments, among them a water level with worm and toothed gear. He worked out the formula for measuring the flow of water through a pipe —but the Romans, for all their 450 kilometers of aqueducts in the Imperial City, never bothered to use it.

He invented a device for mysteriously opening and closing temple doors, worked by a hot-air engine. A fire is built in a hollow altar. The heat expands the air, which drives water from a lower vessel out into a bucket. The weighted bucket sinks, and by a winding chain mechanism, opens the doors. When the fire is extinguished, the water syphons out of the bucket, and the doors close. The same principle was used to construct a fountain. This is the kind of use to which Hero's engines were put. They never saved a human muscle a foot-pound of work; they were toys only—but magical toys withal. The pious gaped as the temple doors swung open, obviously operated by the gods. Similar engines were used to pour out libations without human agency; brazen figures were made to move, dragons to hiss, trees to emit musical sounds, lamps to trim themselves automatically.

When the *Pneumatica* appeared in English, the Marquis of Worcester and Dr. Papin studied Hero's principles, and by their experiments laid the basis for the engine of Watt. From Hero to Papin, a span of 1700 years, no new prime mover appeared save the cannon, (though Leonardo made some on paper), and even Hero's heat engines remained lost and forgotten for most of the period.

The Middle Ages

So long as Aristotle remained *the* philosopher, invention languished, and even the roads and aqueducts of the Romans fell into decay. Aristotle had little use for the practical application of science. To a Greek freeman, the "vulgar arts" were beneath contempt. The medieval church did its part by turning men's eyes toward heaven, rather than toward the things of this world. But mechanical ingenuity did not quite die. When confession was to be wrung from a heretic, some very pretty mechanisms were evolved to help him find his tongue. They included the rack, thumb screws, boots, pincers, "scavenger's daughter," the dreadful "iron maiden," and the wheel—on which a man was strapped and broken. Indeed the officers of the Inquisition were at once talented anatomists and mechanical engineers. In comparison with their more refined efforts, the guillotine was a gross and clumsy instrument.

Another admirable engine of those days (I use the term in its ancient sense) was the "girdle of chastity," whereby the frail moral nature of woman was bulwarked with a padlocked iron contraption, when, bearing the key, her lord and master went off to the wars.[1] And as he fought, he carried upon his person anywhere from fifty to ninety pounds of articulated metal. The suit of armour of Henry VIII now in the Tower of London, weighs ninety-four pounds. Its mechanical fittings, from vizor to toe buckles, were intricate and remarkable but it has been observed, perhaps justly, that such a mighty harness not only protected the knight from injury, but prevented him from injuring anyone else. Very remarkable also were some of the mechanisms for besieging and defending the castles of those times; the catapults for hurling great stones, the ballistas, the battering rams, the travelling scaffolds upon which the attacking force was pushed up, wall high, to the besieged.

We have to note from another quarter a machine for promoting piety. The Praying Wheel was developed by the Buddhists of Tibet, some centuries ago. It consisted of a cylinder, covered with slips of paper, on which the formula "om mani padme hiom" was inscribed in fine characters. The cylinder was revolved by a crank, and the prayer passed in front of the worshipper from *left to right.* This was important. It was counted a sacrilege to turn the crank in the other direction. The Western world adopted the praying wheel, but changed its form and function. A wheel was hung from the ceiling of a chapel and set in rotation by a chain. When it came to rest, the initiated, by consulting its face, could translate a divine answer to a prayer. Less holy supplicants still worship with such engines at Monte Carlo.

---

[1] The girdle of chastity has been called an apocryphal engine by some scholars, but the old German source book which I used shows a number of woodcuts of various models.

The law of the conservation of energy was unknown in the Middle Ages. This was unfortunate for it led to a fabulous waste of time on the part of many learned students and philosophers, who believed that they could discover the secret of perpetual motion. They sought to build a machine which, once set going, would go on forever. Hundreds of attempts were made. A book in two volumes by Dircks is nothing but a chronicle of these attempts. Here is a model of a hollow wheel fitted with curved spokes between which run leaden balls. The theory is that when given a twist, the balls will run along the spokes and so weight them that the contrivance will keep on rotating indefinitely. Of course nothing of the kind did happen, or could. A 600-pound wheel mounted on modern Skefko bearings can be started with the weight of a silk handkerchief. If given a good twist, it will spin for many hours. This is about as close to perpetual motion as man can ever attain.

The beginnings of science

When the Moors came surging into Spain in the Ninth Century, they brought not only the scimitar, but a fresh breath of new knowledge to the medieval world.

Above all they brought the quantitative method, mathematics for exact measurement, including Arabic numerals with the priceless cipher, the groundwork of astronomy, algebra, surveying instruments, and the compass. Pope Silvester II, born in 940, was one of the first Europeans to breathe deeply of this new air. He was educated in the science of the Arabs in Spain, and became head of the famous school at Rheims. He was the first to use Arabic numerals, and he also invented a time piece. For these and other derelictions, he was widely suspected of being in league with the Evil One.

In 1214 Roger Bacon was born. More than any other man, he deserves to be called the founder of modern science. He openly and passionately challenged *the* philosopher. To the consternation of his world, he attacked Aristotle and all his works. He argued for independent research, and for the formulating of natural laws based upon counting rather than upon armchair speculation. He adapted the lens for use in the microscope, and foretold the airplane, the steamship, the automobile and the suspension bridge. For these reckless impieties, he spent ten years in prison, charged with practising black magic. But for all that the Church and the ghost of Aristotle could do, the minds of men began to march, taking up the work which the Egyptians had laid down, two thousand years before.

The compass was improved and the art of navigation reduced to more quantitative terms. The lens was put to many uses. In 1326 a cannon was cast in Florence. Though the Arabs knew gunpowder, and the Chinese long before them, it was the West which was to develop arms of fire on an eminently practical scale. The initial effect was undoubtedly good. By 1500 it was apparent to all save the die-hards that castle walls and 90-pound suits of mail were helpless before the pistons of the new invention. The back of feudalism, according to some authorities, was broken by an internal-combustion engine. The first Bible was printed in 1456, marking the birth of another machine with effects destined to be as shattering as gunpowder.

But perhaps the most significant mechanism of all was the clock. From many points of view it is the most momentous machine ever devised by man. A philosopher of Concord struck its balance for good and evil, and warned us to throw our clocks and watches over the housetop, before it was too late. The hero of Erewhon, as we have seen, narrowly escaped death for carrying a watch upon his person. If you doubt the all-pervading power of clocks, try living without them for a few days.

Mechanical clocks appeared in Europe in the Tenth Century, and by Bacon's time had become fairly common. In the Seventeenth Century one was to be found in every prosperous household in England. They brought profound changes in human habits. Space divisions became in many cases time divisions. On the railroads, places become not miles, but so many *minutes* apart. "I live an hour from the city." Russians and Orientals have not been broken to clocks; which is why they are always late, stay so long as they are having a good time, eat at unclassified and hopeless hours. Their habits are guided by their inner feelings rather than by a moving hand on a round, staring face. Lewis Mumford, reviewing Wyndham Lewis, holds that our criticism is clock criticism. Music is our chief art because of its beat. We bring out newspapers and magazines on time whether there is anything intelligent to put in them or not. Usually there is not. Styles and fashions are kept "up to the minute." Wage systems are based more on hours than on tangible work. But without the time factor, measurable by a clock, we should never have had the science of physics; never any heat engines beyond Hero's toys; never our billion horsepower. Physics is nothing but a series of conclusions derived from time measurements, space measurements, mass measurements.

The gaudiest clocks of history were built as Europe began to take Bacon to heart. One can still find them on the ancient Rathaus with dial upon dial; with moving life-size figures—angels, birds, cupids, saints. Also there was a great development of small clock-work toys. The skilled clock maker of the Fifteenth Century must have done much to pave the way and prepare the tools for that skilled steamfitter to whom Watt in his extremity could turn.

Leonardo

The lamp which Roger Bacon lit flickered from time to time, but grew stronger down the centuries. It streamed along the highroads of the Renaissance. The engineers of Italy after 1450 began to calculate on paper and to measure. They did away with the inclined plane, and substituted lifting devices, block and tackle, windlass, crane—much like those we use on small construction work today. But Leonardo, perhaps the most astonishing genius born of woman, and certainly the greatest engineer that ever lived, did not stop here. He went on to heights which even the Twentieth Century can only glimpse. An effective presentation of his accomplishment lies in a simple list of some of the mechanisms with which his note books are filled. These note books, for their sketches alone, constitute a treasury of art. It is interesting to go through a volume of old engineering drawings, and, without looking at the names, unfailingly pick those of Leonardo from the rest.

He anticipated Copernicus on planetary motions, and Newton on gravitation.

He surmised that the earth revolved.

He discovered the earth shine on the dark of the moon.

He reconstructed animals from fossils.

He analyzed the molecular composition of water.

He worked out a theory of wave motion, and the undulation theory of light and heat.

The first plus and minus signs in Italy were employed by him.

He studied the formation of regular polyhedrons.

He deduced that fire feeds on an element in the air.

He worked out the laws of a lever moving on an inclined plane, and formulæ for the volume of water needed to fill canals.

The density of gases he measured.

He made extensive studies of the composition of explosives.

The tides he attributed to the pull of the sun.

He invented the barometer, and projected the thermometer.

He improved the compass and the balance.

Cams, gears, worms, ratchets, sprockets, chains, were all used by him.

A stone-cutting saw of his invention is still in service in a Carrara marble quarry.

He designed a steam boat, steam pumps and a steam cannon.

He designed buoys, diving apparatus, and the first life preserver.

He designed rolling mills, draw-benches, power-hammers, cranes, threading machines, file-cutting machines, rope-making machines, lathes, planes, boring mills, jigs, chucks, bending machines, multiple cloth cutters, jig looms, dredges, and a machine for drawing and rolling iron staves.

Automatic machinery for needle grinding and gold beating was known to him.

He planned a radius grinder for wire in the manufacture of concave deflectors.

He designed catapults, ballistas, cross-bows bent with windlasses, scaling and battering engines, breech-loading cannon, artillery carriages, multiple-barrelled guns.

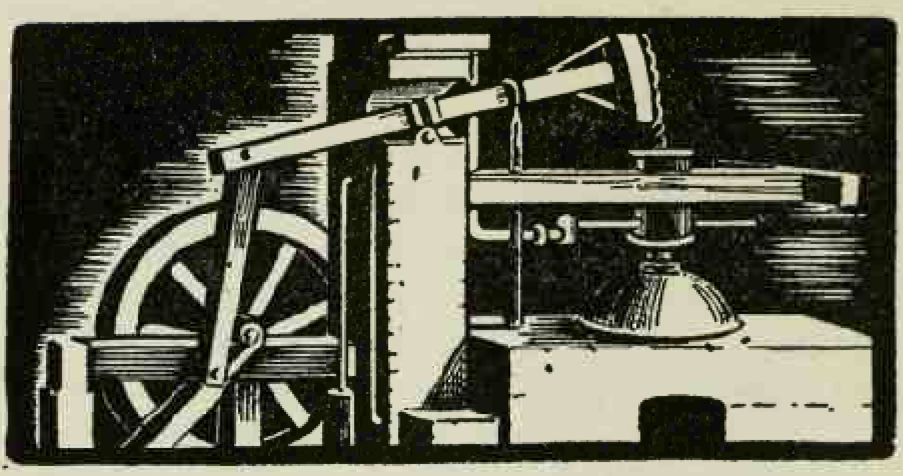
He knew the use of the parachute.

He designed airplanes, ornithopters, and helicopters.

But he never solved the method for working iron to close-fitting surfaces, and so the Machine Age had to wait for another two hundred years.

The Venetian approach

Rome looted for her wealth, Venice traded for it—thus keeping both buyer and seller reasonably healthy. Spain looted her colonies and died of an overdose of Peruvian gold. England followed the Venetian system and throve. Indeed she improved upon the Doges, whose cargoes were silks and spices, by carrying cargoes all over the world for the common man—tea, molasses, tobacco, sugar. "Cargoes not for the palace or cathedral, but for the alley and cottage." This trading, besides spreading civilization, did two things of prime importance to our story. It made for resourcefulness and ingenuity on the one hand, and it cried aloud for more power on the other—power for transportation, and power for the manufacture of cheap textiles which the trade demanded. The Renaissance had enormously improved tool-machines, and had taken the lead away from the Arabs and the East. Metallic carders were being used by the guildmen of Florence; water power was driving spinning mills in Bologna and paper mills in Nuremberg. There were no slaves in England, while the rising class of traders would permit of no philosophy which looked down upon the "vulgar arts." It was by the vulgar arts they made their living. The time was ripe for a prime mover, more mobile than water, less fickle than wind, more useful than Hero's toys. It came.



CHAPTER IV

FROM JAMES WATT TO THE MECHANICAL MAN

In popular mythology, James Watt invented the steam engine. The idea came to him as a boy while he played with the kettle on the stove. Both statements are untrue. He did not invent, but improved the steam engine; and his first experiments were made when he was twenty-eight. He transformed it from a lumbering, leaky freak, to a business-like machine that saved untold man-power in all sorts of industries. For that great accomplishment he is justly honoured as the father of the industrial revolution, and his name enshrined to perpetuity in the word "watt"—which is the standard world unit for measuring power.

Thomas Savery in 1698 had invented a practical prime mover to pump water, using steam to create a vacuum—the culmination of experiments based on the translation of Hero's book. He called it "The Miner's Friend, or an Engine to Raise Water by Fire." Newcomen, a few years later, had got a great beam clanking back and forth by virtue of an atmospheric engine. The former could run a fountain for a gentleman devoted to the philosophy of conspicuous consumption; the latter, if its boiler did not burst and its valves melt out, could coax a little water out of the bottom of a coal mine. (The "Miner's Friend" was good for only twenty feet.) Both were prodigiously wasteful of fuel.

Young Watt was an exceptionally gifted tinkerer. By trade a maker of mathematical instruments, he could turn his hand to anything, repair all sorts of mechanisms. As a musician he hardly knew one note from another, but if an organ was out of kilter, he could not only make it play again, but play better than before. Once, for a whim, he made a very fine guitar. All of which proves once more that musical instruments and steam engines have much besides noise in common. When still short of thirty, he was called in to repair a model of a Newcomen engine, which had never performed well since its installation at the University of Glasgow. As he tinkered, he speculated upon the problem of the cylinder, which had to be heated by steam and then cooled by water to create the necessary vacuum. Was there no better way to condense the steam and create the vacuum than to discourage the cylinder every few seconds by dousing cold water over it?

The solution came to him one Sunday afternoon—it was in the spring of 1765—as he walked over Glasgow green toward the Golf House. Why not attach a separate vessel to take the cold bath and do the condensing, thus allowing the cylinder to remain hot all the time? He set to work on the notion, and before long had contrived another metal box, to which the steam could regularly escape and be condensed, and so permit the cylinder, now steadily hot, to transform far more of the heat of the coal into work. (The exact formulation of the laws of thermodynamics was to come with Kelvin, years later.) The new "condenser" hardly performed to perfection, but, by the Eternal, it performed. It made the steam engine a going concern, and Watt immortal. He had tinkered his way to Olympus but he kept on tinkering. The invention of the condenser was his outstanding achievement; it was followed, however, by a series of beautiful mechanical discoveries and improvements.

He took out his initial patent in 1769, but his first really successful engine was not running until 1776. It began to grind, fourteen strokes to the minute, as the American colonies declared their independence. By 1800, when his patents expired, his engines were in mines, foundries, textile and paper mills, and being experimented with for carriages and boats.

Watt never dared use steam at high pressures, because the art of steam fitting was still in its infancy. In consequence, his engines tended to be very large and very noisy, great clanking monsters. In the early models the piston was aimed at the sky, and set an overhead walking beam rocking back and forth. As time went on he tried, as a good engineer, to quiet them, but he met with little encouragement. He tells us:

> At present the velocity, violence, magnitude and horrible noise of the engine give universal satisfaction to all beholders, believers or not. I have once or twice trimmed the engine to end its stroke gently, and make less noise, but Mr. B—— cannot sleep unless it seems quite furious, so I have left it to the engine-man.

From which it appears that many took the steam engine as an act of faith, and once they had taken it, the more ferocious the manifestations of the new god, the better.

Why the industrial revolution came in England

We have seen how the first sparks of the industrial revolution were scattered by the Moors, when they pushed north into Spain with their Arabic numerals and their instruments of precision. We have seen how Pope Silvester II, Roger Bacon, and Leonardo fanned the glowing cinders into a respectable blaze. In Italy, France, the Low Countries, bright fires were burning, but it was in England that a great tongue of flame and smoke went mounting to the sky. In England the industrial revolution was officially born, and for at least a century she was destined to be its chief guardian. Birmingham and Manchester were to become roaring factory cities while the scattered farmers of America still used the tools the Egyptians had invented; still took their grain to the old stone mill beside the river.

All the reasons for the outbreak in this particular spot at this particular time—the north of England in the middle of the Eighteenth Century—will probably never be completely known. Patient scholars, however, have identified a number of them, some of which have already been mentioned. Summed up, the outstanding causes seem to be:

The growth of the scientific spirit; the substitution of quantitative evidence for armchair speculation. The weakening of the medieval tradition.

The development of the science of measurement, and thanks largely to navigation, the increase in the number and accuracy of instruments of measurement—clocks, quadrants, compasses, levels, telescopes and the rest.

Refinements in metal working.

The absence of a large slave class to do the heavy work.

The end of corporation and guild restrictions. An extension of economic freedom, putting a premium on personal initiative.

A surplus of capital, due to the profits made from the great volume of overseas trade—the trade which was wrested from Spain, Holland, and the Hanseatic League.

A stable monetary system based on the gold of the New World—which Spain had borne all the expense of securing.

The fact of being an island, and so immune from disrupting wars fought on her own soil.

A high degree of internal political stability—in marked contrast with the Continent; and a high degree of cultural uniformity.

A surplus of free labor, due to the Enclosure Acts which drove farmers from their traditional fields.

Coal, iron and waterpower, bunched and available in the north of England.

A network of good roads and canals which greatly facilitated trade and transport.

A humid atmosphere good for textile manufacturing.

A growing textile industry, already operating in large units. The output was a strong coarse cloth, and thus readily adaptable to machine rather than hand manufacturing.

And perhaps most important of all, a profitable *demand,* from all over the world, for cheap, staple English products.

Engines did not come to save men the brutality of dull labour, to help an Emperor build an imperial city, to irrigate and replenish waste lands—they came because English traders wanted to increase their profits by making cheaper cotton to sell abroad. The human values, such as they were, had to enter by the back door, and despite much lofty talk to the contrary, this is the route which they still follow.

Meanwhile popular psychology was making itself ready for mechanical wonders, eager to see them and encourage them. When Silvester II tried to construct a watch, he was widely suspected of being in league with the Evil One. But for Watt and his fellow inventors there was a craning of necks and a clapping of hands. In 1764 the *Wonderful Magazine* made its debut—the grandsire of our own *Popular Science* and *Popular Mechanics.* There was much public excitement concerning "aerostatic experiments," balloons, horseless carriages, submarines. In 1772 Mr. Cox's Museum in London had no less than twenty-two mechanical exhibits. I quote from the catalogue:

> Piece the Fifteenth is a chronoscope in the form of an obelisk under a great and magnificent canopy with profuse ornaments and a prodigious variety of motions. It stands in the center of a rich gallery, upon a table . . . upon which an elephant moves around the obelisk. Upon his back is a castle of gold; within the castle is a curious clock with three dials; on the top of the castle are automaton figures, playing various tunes on twelve bells; over the music gallery is a figure that strikes the hours and the quarters; above that a pyramid of moving stars which terminate in four dolphins, in the middle of which is an animated dragon, dropping pearls into one of the dolphin's mouths, moving his wings at the same time.

Cotton

Watt's engine was first used to furnish power for textile machines. It is important to remember that the machines were there before the engine—some of them preceded it by a generation. They began the curve which Watt turned into a full revolution. In 1700 the technology of spinning and weaving cotton, wool and linen, was practically unchanged from the methods used in Egypt in 5000 B.C. In 1738 Kay invented the flying shuttle for weaving cotton, and broke the spell of primitive methods. This mechanical shuttle made it possible for one man to manage a wide loom single-handed, replacing the old practice where two men passed the shuttle from side to side. Before long, the invention was in general use in England, with the result that cotton cloth could be woven faster than thread could be supplied to the looms. The spinners could not keep up with the weavers. Invention inevitably tried to close the gap. The industrial revolution is nothing but one eternal struggle to close technological gaps.

In 1764 Hargreaves produced the spinning jenny which made one wheel operate eight spindles (before long 100 spindles). Then came the roller spinning-frame attributed to Arkwright, worked by water power, which forced spinning out of the cottage and into the factory—and caused the word "spinster" to lose its economic meaning. Arkwright incidentally was one of the most enterprising mechanical thieves that ever lived. In another decade Crompton's spinning-mule—a hybrid combination of the jenny and the frame—was producing finer and stronger threads than any known before.

These three great improvements more than closed the gap. The weavers could not keep up with the spinners. Invention swung back to the loom. Dr. Edmund Cartwright, a clergyman of Kent with a mathematical turn of mind, devised a loom to be run by water power. It was a clumsy mechanism, but laid down important principles, and was rapidly improved. (Not until 1820, however, did the last hand weavers leave their cottages and file, beaten, into the mills.)

Spinners and weavers were now neck and neck. They began to be impeded for lack of raw cotton. An American inventor came to their assistance. Eli Whitney completed the circle with his cotton gin, which cleaned the seeds from field cotton more than 100 times faster than negro slaves could pick them out. The brake which kept cotton planting down was suddenly released, and both growing and manufacture leaped forward.

The cotton circle was complete; a balance was struck between cleaning, spinning, weaving, and printing the finished fabric—the latter process invented by Bell in 1783. The textile center of the world moved from India to England. But industries have shifted from nation to nation throughout recorded history. The new machines, operated either by hand or by the groaning water wheel, would have made history, but hardly a revolution. Their power was too circumscribed; the rhythm of their output too sedate. If a new world was to be created, they wanted speeding up; double time, triple time, a hot and riotous tempo, lit by fires never seen before on land or sea. . . . The Watt engine was first yoked to cotton mill machinery in 1785. The industrial revolution had officially begun!

Machines for manufacturing cotton were before long taken over, with necessary modifications, by the woolen industry. Some modern engineers hold that the most ingenious of all mechanisms is the automatic woolen spinning-mule, relieving the weaver "even of the responsibility of seeing that the shuttles contain yarn." Meanwhile, by 1857, it was possible to say that "the present spinning machinery is a compound of about

800 inventions." No more effective illustration could well be given of the fact that invention is normally a social process, rather than the work of a few great men. We writers try to make our pages dramatic by concentrating on the geniuses, but inevitably we distort the story. Even Watt might have spent his life on chronometers and organs, had it not been for Newcomen; while if Watt had died at birth, the chances are that a condenser would have been invented before 1800.

Iron and iron horses

Looms and spindles may have helped to start the industrial revolution, but they did not finish it. It was never called the Textile Age. It has been called the Iron Age, the Age of Steam, the Coal Age, the Machine Age. Lately we hear, depending on the trade association involved, the Oil Age, the Electrical Age and the Motor Age. In a year or two, the Air Age will be a well-worn phrase. While there is something to be said for all these appellations, we know the most just to be the Power Age; it holds without qualification from Watt to Diesel.

If the power engine was the hero of the industrial revolution, iron and coal were its parents. The three together formed the new holy family of materialism. Acting and reacting upon one another in countless combinations, they made possible the billion horses which are either serving us or running away with us today.

The coal mine fed the engine, and the engine in return pumped water out of the mine, hoisted coal out of the pits, helped to carry it by rail and water to its destination. Coal smelted the iron, and its coke helped to make the steel out of which the engine could be formed. Iron was a cardinal factor of equipment in operating the mine—picks, shovels, cables, drills. Finally, the engine became a fundamental requisite in working iron. Its job was to furnish the forced air for the blast furnace. Such interrelations are of the essence of the Power Age.

As typical of many industries, let us glance at what the industrial revolution did for the ancient art of mining. In the Eighteenth Century mines were opened and their ores removed with the pick, shovel, crowbar, sledge hammer, and an occasional charge of black gunpowder. The ore was hoisted by a rope from the pit, and hauled away in carts, or on the backs of pack horses. Buckets of rawhide took care—or tried to—of surplus water in the mine. The Egyptians could do about as well.

Then came the hand-operated windlass, and the horse-operated whim, to lift the ore. Wooden cars running on wooden rails supplanted the box and rawhide sack. Another decade or two, and a Watt engine was puffing and blowing at the pit mouth, operating a steam hoist and a pump. Now changes come thick and fast. Dynamite succeeds black powder. Cars pushed by hand give way to mules, and finally to dwarf locomotives. A compressed air drill supplants the hand drill. The iron hoisting bucket disappears before a cage like a freight elevator for handling cars direct from the working levels to the surface. The skip hoisting equipment is introduced. The hand shovel is supplanted by mechanical loading machines. The individual steam plant is replaced by a central power station furnishing current for lights, electric hoists, air compressors, pumps, and motors for underground haulage. Finally come multiple car tipples, automatic hoists, coal-cutting machines (in coal mines), elaborate ventilating systems, and a steam turbine for the central power plant. Nor is the end in sight.

A Frenchman named Joseph Cignot built a steam carriage to run on a highway in 1769. It never ran far. In 1804 Richard Trevithick constructed a steam carriage to operate on a horse tramway in Wales, the first man to apply a steam engine to a road of rails. But the initial practicable locomotive was George Stephenson's "Rocket," which began to alarm the British countryside in 1829. Its cylinders were set on a slant and worked directly on the rear wheels; it was only good for fifteen miles an hour; its thermal efficiency was undoubtedly less than one per cent, but it paid its way. It gave Watt's engine the task of diminishing space, and presently, in America, the overtaking and elimination of the covered wagon.

The first practical steamboat was the *Charlotte Dundas,* a tug built by William Symington and tried in the Forth and Clyde Canal in 1802. It had a Watt engine, yoked to a paddle-wheel in the stern. In 1812 came the *Comet* with side paddle-wheels. Meanwhile Robert Fulton in 1807 put a Watt engine to work on the Hudson River in his *Clermont.* It proved to be the first commercially successful steamboat, and with its coming the sailing ship was doomed. In 1837 a steamship crossed the Atlantic Ocean. One glorious dying flare there was, in the Yankee clippers of the fifties—perhaps the most beautiful things ever fashioned by the hand of man—and then the pall of smoke descended to put the new trinity—coal, iron and steam—in supreme command of the seas.

A clumping engine stands in a Lancashire mill turning a flywheel; and by a system of leather belts as complicated as it is precarious, the jennies are twirling their 20 spindles, with little children standing beside to mend the broken threads. We have told a little of how power came to cotton, to coal, to transportation. To follow the history of the industrial revolution in any detail, we should have to tell how it came to pottery, printing and paper, lumber, a score of industries. This is not a history, but only a layman's glance at Watt and his friends; a glance before the avalanche of new inventions descends in a matted mass requiring the most exhaustive research to untangle. The broad outlines of the revolution have been described by many competent historians, and to them the curious reader is referred. The interim—profoundly important as it is—will have to be bridged by the table on pages 78-79, and the few notes which accompany it. The table overemphasizes American inventors since it is compiled chiefly from American sources, and makes no attempt to give emphasis to Mr. W. F. Ogburn's beautiful work on duplicate inventions.

Electricity and petroleum have joined with coal, iron and steam to make the power family five.

On September the fourth, 1821, Michael Faraday, at the Royal Institution in London, tied a magnetized needle to the bottom of a cup. Into the cup he poured enough mercury to float the needle upright. He then lowered a wire, connected with a battery, until it touched the mercury. Instantly, and to the beholders miraculously, the needle began to revolve around the wire, and continued to do so as long as the current flowed. In that little cup the electrical industry was born. Faraday had demonstrated the *interchangeability of electrical and mechanical power.* A current had made a bit of steel revolve. Why not the reverse; why not revolving metal to generate a current? For ten years he worked on the problem. In 1831 he wrote to a friend: "I think I have got hold of a good thing but can't say. It may be a weed instead of a fish that, after all my labour, I may pull up." But a fish—indeed a veritable whale—it was. He had demonstrated that when a magnet is thrust into or withdrawn from a coil of wire, a pointer on an instrument connected with the wire moves slightly. He had generated an electrical current by means of a moving magnet. Soon he had a

SOME OF THE GREAT INVENTIONS OF THE INDUSTRIAL REVOLUTION

Date	*Invention*	*Inventor*	*Country*
1784	Reverberatory furnace	Cort	England
1800	Galvanic battery	Volta	Italy
1800	Paper-making machine	Fourdinier	England
1804	Screw propeller	Stevens	United States
1807	First commercially successful steamboat	Fulton	United States
1816	Stethoscope	Laennec	France
1818	Milling-machine	Whitney	United States
1827	Water turbine	Fourneyron	France
1828	Electromagnet	Henry	United States
1829	Locomotive perfected	Stephenson	England
1831	Dynamo	Faraday	England
1834	Reaper	McCormick	United States
1835	Electric telegraph	Morse	United States
1835	Revolver	Colt	United States
1837	Electric motor	Davenport	United States
1839	Electrotype	Jacobi	Russia
1839	Photography	Daguerre	France
1840	Steamhammer	Nasmyth	England
1845	Turret-lathe	Fitch (Stephen)	United States
1846	Sewing machine	Howe	United States
1847	Rotary press	Hoe	United States
1851	Electric locomotive	Vail	United States
1861	Machine gun	Gatling	United States

1865	Bessemer Steel	Bessemer	United States
1867	Dynamite	Nobel	Sweden
1870	Electric steel furnace	Siemens	Germany
1876	Telephone	Bell	United States
1877	Gas engine (four cycle)	Otto	Germany
1877	Phonograph	Edison	United States
1878	Incandescent lamp	Edison	United States
1884	Steam turbine	Parsons	England
1884	Linotype	Mergenthaler	United States
1886	First safety bicycle	Pope	United States
1886	Aluminum process	Hall	United States
1887	Kodak	Eastman	United States
1887	Trolley car	Van Depoele & Sprague	United States
1888	Recording adding machine	Burroughs	United States
1893	Motion picture machine	Edison	United States
1893	By-product coke oven	Hoffman	Austria
1895	X-rays	Roentgen	Germany
1896	Radioactivity	Becquerel	France
1896	Wireless telegraphy (high frequency)	Marconi	Italy
1896	Airplane	Langley	United States
1900	Diesel engine	Diesel	Germany
1901	High-speed steel	Taylor & White	United States
1901	Airship	Santos-Dumont	Brazil
1913	Tungsten filament light	Coolidge	United States
1927	Television	Bell Laboratories	United States

little rotating apparatus which gave out current continuously—and the principle of the dynamo was given to the world. But it took another generation to establish its utility.

In the same year, Joseph Henry, the first secretary of the Smithsonian Institution at Washington, also drafted a communication. It read:

> Sir:—I have lately succeeded in producing motion in a little machine by a power which, I believe, has never before been applied in mechanics—by magnetic attraction and repulsion. Not much importance, however, is attached to the invention, since the article, in its present state, can only be considered a philosophical toy.

Last year the great-grandchildren of that philosophical toy produced upwards of 50,000,000 horsepower in the United States. These two letters show the humility which lies in the hearts of great men of science, and, furthermore, how closely they sometimes tramp upon one another's heels.

Niagara was harnessed in 1895. A year later, the steam turbine was introduced into America, and also began to run dynamos. The limit in size for reciprocating steam engines had about been reached. A 10,000 horsepower unit for the New York subways was built in 1899 and towered forty feet into the air. It was good for one hundred years of service, but by 1902, the turbine had reduced it to the value of scrap iron. The same work could be done by an engine one-tenth the size, consuming far less coal.

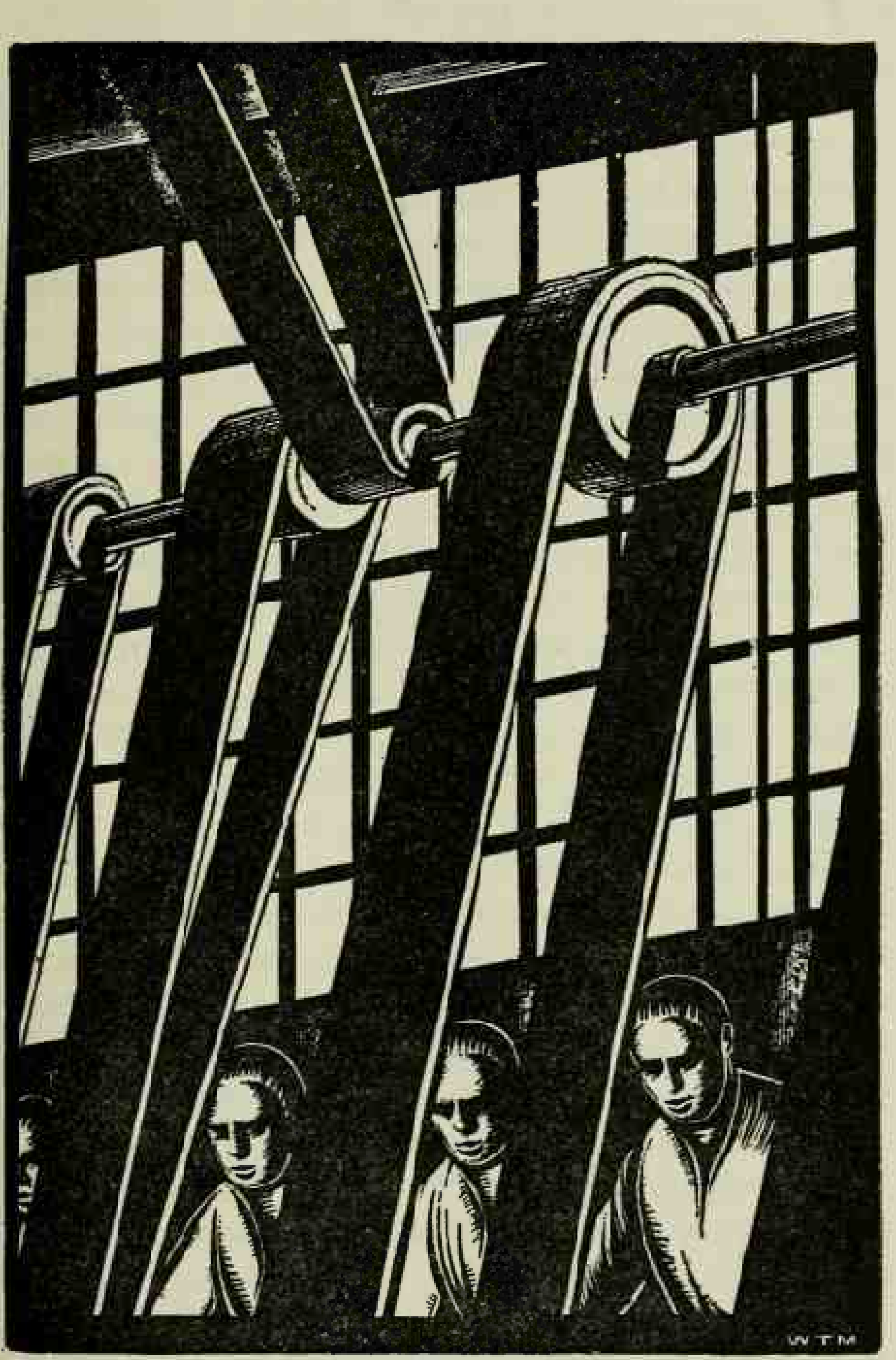
Here we have another basic characteristic of the Power Age: the head-long rate of obsolescence. Good machines are continually being supplanted by better ones—a long road lined with the wreckage of superseded inventions. The breeding of machines is almost as wasteful a process as that by which Nature develops and discards her living models.

Before the gasoline motor could be bred, petroleum had to be located in paying quantities. On August 23, 1859, after nearly going bankrupt as a steam drilling machine gnawed its way through solid rock, a certain Colonel Drake brought in the first petroleum well in America, at Oil Creek, Pennsylvania. Oil was struck at a depth of sixty-nine feet, "the golden liquid half filling the hole." A small pump yielded 1,000 gallons a day. The speculators began to swarm, and have been swarming ever since. Nearly 800,000,000 barrels of the golden liquid are now being hoisted out of the subterranean caverns of the United States annually, of which a large proportion goes to drive internal combustion engines. At the present time, we can get a horsepower for every pound of metal in an airplane engine, while half a pint of gasoline will produce a horsepower for an hour. The old Watt engine produced a horsepower for every *ton* of metal. The improvement in energy per pound is thus something in the nature of two thousand to one.

When we think of oil, we think of gasoline, motor cars, airplanes, fuel oil, Diesel engines, and possibly of the lowly kerosene—which once was the only reason for pumping it out of the ground at all. We seldom think of what is perhaps the most important factor of all in a barrel of petroleum. There is not very much of it, but without it most of the prime movers and machines in the world today would grind, smoke, sputter and come to a dead stop. They would never start again without lubricating oil for those portions of their anatomy where moving metal bears on metal. "In our attention to the generation of power, we give too little thought to the unique function of oil—that of saving power. Machinery without lubrication is unthinkable." When oil begins to fail, as it may in the next decade, my guess is that the last bearing wells will be husbanded primarily for lubricating purposes.

Steam, coal, iron, electricity and oil are the cardinal elements of the Power Age, and those which secure the most publicity. Meanwhile all manner of less trumpeted inventions and developments have been of vital importance in locking the industrial structure together, and making it function as a technological whole.

Here, for instance, is the Michell thrust block. "It is not too much to say that the possibility of successfully driving our largest ships is due to the principles of lubrication worked out on paper by Mr. Michell. The enormous thrust of their great screws may be said to

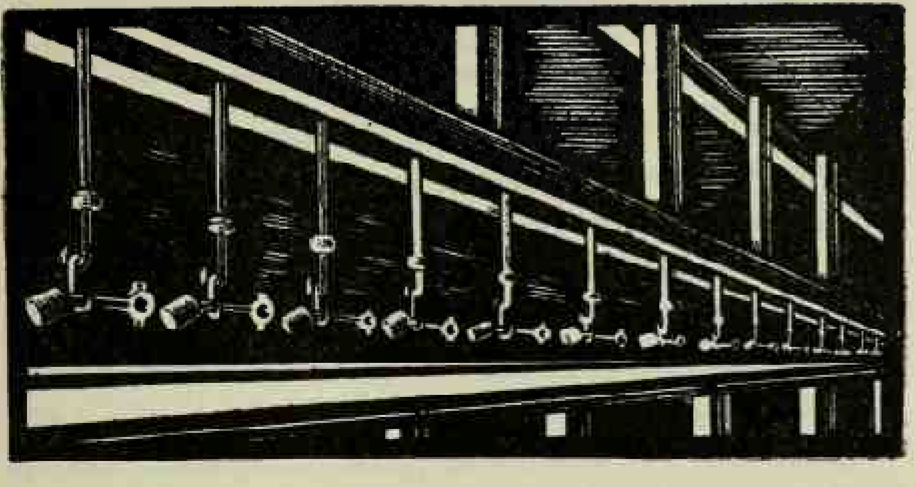

WTM

be pushing up against a few pages of mathematics." (Again the zero.) A revolving propeller generates a terrific "kick back." For a ship of 12,000 horsepower, the back push is one hundred and ten tons at twelve knots an hour. To take this push, a strong collar has to be put on the propeller shaft to keep it from disembowelling the hull. Before Michell, large ships demanded a whole series of these collars; the *Britannic,* built in 1914, had fourteen of them, one behind the other, fed with great quantities of lubricating oil and water to keep the mechanism cool. Then Michell, with a pad of paper, and an assortment of Greek letters and logarithmic signs, worked out the behaviour of viscous liquids. He found that when one flat surface moves over another flat surface at a small angle, with oil between them, the oil is forced into a wedge-shaped space, and lifts the moving surface clear of the stationary one, reducing friction close to nothing. Applying the equations to the problem of the thrust block, the fourteen great steel collars and all their assisting contraptions go into the scrap heap before a simple ring of metal with a bit of oil inside it. The oil humps up according to the formula, and takes the whole thrust of the propeller!

Again, take dynamite. Without explosives we could not mine enough coal and iron, the country over, to keep one fair-sized steel plant operating. Without Frederick W. Taylor's discovery of high-speed steel, a Ford car would cost five times as much to make, and require a plant many times larger for the same production. If Charles Goodyear—or someone else—had not happened to throw rubber and sulphur by accident into a fire together—and so stumbled upon the principle of vulcanization—where would the automobile industry be? The shoe industry could never have gone into mass production without the discovery of chromium salts for the treatment of leather. Reaumur, studying wasps' nests, laid the foundation for the modern paper industry. Failing it, we should have had no tabloids—which perhaps registers another count against the wasp.

And yet for all the thousands of inventors and their achievements—those advertised and the others more demure—nobody has developed to date a generally practical device for felling trees. Nearly every tree used for lumber or for paper has still to be chopped or sawed by hand. And when we come to think of it, despite the labour and the hardship, there is a touch of romance in the fact that the faithful axe, the friend of man for one hundred thousand years, remains the king of the forest.

rats, trees are cut down by a [illegible].



CHAPTER V

FROM JAMES WATT TO THE MECHANICAL MAN
(*Continued*)

ENGLAND, as we have seen, was the birthplace of the industrial revolution, but her engines were not long in spawning throughout the Western world; not long, that is, from the point of view of the stately processes of cultural diffusion. It took gunpowder a thousand years or more to get into Europe from China, but a Watt engine reached America by 1790. Today there are modern machines, if no more than firearms, in every community on earth, but the Power Age as such is restricted to a rather definite area, broadly covered by the term Western civilization. It includes Europe except Russia, Poland, Hungary, and the Balkan States, with an infection distinctly minor in Spain, Portugal, Greece and Southern Italy. It includes North America between the Rio Grande and the line of the Canadian National Railways. It is beginning to include the

Argentine. Strangely enough it includes to a limited degree Japan—6,000 miles beyond the boundaries of the West; and not so strangely, Australasia, whose culture is almost entirely English.

In France as in England it came first in the shape of looms for weaving cloth. In 1789 the textile production of France equalled that of England. In 1835 England's was four times as great. Napoleon encouraged machinery and did more for Jacquard and the loom he invented than the British Government ever did for Kay or Crompton or Hargreaves. But with the loss of Belgium and its coal mines, and the profound economic depression following Waterloo, France began to fall behind. In 1816 the French textile mill averaged 60 persons, to 300 in Manchester. Even to this day France is not a highly industrialized nation, except in limited areas. Her specialty has always been fine goods with a predominance of handicraft, rather than the cheap and sometimes nasty floods of mass production.

Germany began to make real industrial headway only in 1871, at the close of the Franco-Prussian War, and went as far in the next twenty years as England had gone in the previous century. In 1914 she was probably the foremost industrial state in the world. Nor is it by any means certain that that lead has been permanently lost. The valley of the Ruhr is still the greatest single industrial exhibit in the world.

Italy began to industrialize in 1850 under Cavour. Northern Italy is a great manufacturing area today. But the peninsula holds no coal and iron—a shortage which is largely responsible for certain of the more belligerent gestures of Il Duce. Austria followed Germany in the 'seventies, locating her factories predominantly in Czechoslovakia, where they are still very active. Hungary and Russia never really got under way at all, but little Belgium with her coal, and the tradition of the famous cloth-workers of Flanders, early and eagerly borrowed—to use no harsher term—the British inventions, and proceeded to mechanize herself.

Japan's sudden adoption of machinery was even more astonishing than Germany's. Starting twenty years later, in the 'nineties, the process never went so far or so fast, but when one remembers the stern taboos and traditions among which engines had to be grafted—upon an island without coal and iron, 6,000 miles from any kindred centre—one wonders how they ever survived upon those shores. When Perry came to Yokohama, he might have been looking into Babylon or Memphis, save that there was far less experimentation in the air. Yet a few decades later, there were hundreds of smoking factory chimneys. Someone should give a sound book to the psychology of the phenomenon. If 50,000,000 people can be jumped over 5,000 years of history in a couple of decades, what becomes of the argument as to "unchanging human nature"?

The infection cannot be said to have become chronic in the United States until the Civil War, nearly a century after it broke out in England. "Yankee ingenuity" is a well-grooved phrase, but it applied more to tools and hand-operated mechanisms than to power engines. Cotton mills appeared in New England after the turn of the century; British inventions were smuggled in and copied; but until the 'sixties we continued to be chiefly a rural people. Our main energies went to the settling of the West, although we managed meanwhile to produce some outstanding inventors and inventions, as the table in the last chapter shows. We trailed England and Germany through the 'eighties, 'nineties, the first decade of the new century; probably up to 1914, growing ever stronger and more obstreperous. It was not till after the War that the sparks of mass production and automatic machinery, which we had been quietly nursing for some years, burst into flame, and stupefied the world. America did not invent mass production, indeed it is implicit in the technical evolution of the machine, but it developed the process beyond anything accomplished in other countries, and in the opinion of competent observers laid what amounted to a new industrial revolution upon the bed of the old. Our methods are now being studied and imported by other nations; though such a stupendous organization as the Krupps' in Germany has perhaps as much to give as it has to take. To a consideration of mass production we shall presently address ourselves in some detail, for of all manifestations of the machine it is considered, by certain of the gloomy philosophers, the most fraught with evil to mankind. (Both here and in the preceding chapter, our concern is predominantly with the mechanism, rather than with its social effects.)

National and world power

Mr. T. T. Read, a competent statistician, has attempted to calculate by nations the relative output of work per person. His figures serve as a rough index of mechanization in the modern world.

Relative Work Output

China	1
British India	1.25
Russia	2.5
Italy	2.75
Japan	3.5
Poland	6
Holland	7
France	8.25
Australia	8.5
Czechoslovakia	9.5
Germany	12
Belgium	16
Great Britain	18
Canada	20
United States	30

The following figures compare coal production with the population of England since 1800. England has very little water-power and no oil, so her coal roughly measures the growth of her engines since the industrial revolution began.

	Coal		*Population*	
	Tons	*Index No.*	*Index No.*	*Persons*
1800	10,100,000	21	50	8,900,000
1810	.....	..	57	10,200,000
1820	14,000,000	29	67	12,000,000
1830	16,100,000	33	78	13,900,000
1840	35,000,000	71	89	15,900,000
1850	49,000,000	100	100	17,900,000
1860	80,000,000	163	112	20,100,000
1870	110,000,000	224	127	22,700,000
1880	147,000,000	300	145	26,000,000
1890	181,000,000	371	162	29,000,000
1900	225,000,000	460	182	32,500,000
1910	264,400,000	540	202	36,100,000
1920	230,000,000	470	212	37,900,000

The year 1850 is taken as 100 in order to prevent the power growth from looking too fantastic. From that year to 1920, while population increased 112 per cent, power as represented by coal output shot up 370 per cent, with an even higher peak in 1910. (The depression following the War is registered in the 1920 figures—a depression which still continues.)

Mr. F. G. Tryon furnishes the United States with an accurate index, not of power, but of energy—which includes both mechanical power and heat. It also includes the power of work animals reduced to a mechanical equivalent. The year 1899 is taken as 100.

	Total energy	*Physical production*	*Population*
1870	18	56	51
1880	33	75	66
1890	70	78	83
1899	100	100	100

	Total energy	*Physical production*	*Population*
1905	156	145	111
1910	203	160	121
1915	218	180	134
1920	271	210	139
1926	310	260	155

The industrial revolution in the United States began in earnest in the 'sixties; mass production commenced to get under way after the turn of the century. Note how both energy and production increase after 1899, as contrasted with population, thus reflecting the new technique; the "new revolution" as Mr. R. G. Tugwell styles it. Energy since that year has grown precisely twice as fast as population.

Half of the total energy budget, the equivalent of nearly 500 million tons of coal, is consumed as heat. We think of heat as the warming of buildings to live in, but industry uses more than all our homes and offices combined. Iron and steel are ravenous users of heat; requiring far more of it than motion energy. "The industrial revolution was no less a period of sudden advance in the art of applying heat than in the art of applying motion."

We have repeatedly spoken of the billion horsepower of the modern world. The time has come to prove it, and we find that the figure is not poetic license, but probably an underestimate. Mr. F. R. Low, editor of *Power,* has circulated the total capacity of prime movers, as follows:

	Horsepower
United States	704,000,000
England	175,000,000
Germany	175,000,000
France	70,000,000
Total Four Nations	1,124,000,000

In a letter to the author, the *Geological Survey* estimates the United States totals for 1923 (since when there has been a great increase):

	Horsepower
Automotive engines	507,300,000
Steam railroads	74,600,000
Electric central stations	22,000,000
Manufacturing	19,700,000
Agriculture	18,300,000
Ships	10,300,000
Mines	5,000,000
Electric railways	4,100,000
Irrigation	1,300,000
Total United States	662,600,000

This total and that of Mr. Low are in reasonable agreement—and note the enormous fraction of all power for which the automobile is responsible. Here is a billion and more of horsepower in the four great industrial nations alone. Several hundred million additional would have to be added before the world aggregate could be struck. Can the grand total be far short of a billion and a half?

Before Watt's time we had the muscles of men and of animals. Now we have added the muscles of nine billion additional men (assuming the conservative ratio of six men to the horsepower); enough to increase the present population of the world by five—and all able-bodied males! Remember, however, that these new muscles only work spasmodically; remember the number of hours that your car rests in the garage; remember the thousands of cold factory engines on any work day, the idle locomotives, the docked steamships, the silent tractors—and do not lose your perspective when contemplating the nine billion mechanical men. At any given time great numbers of them are taking a siesta.

Mass production

When I was a youngster I had a passion for building little battleships out of wood. Having got a fleet of a dozen sail together after weeks of labour, I would set them afloat on a pond, and in a few delirious moments pound them to pieces with an air rifle. The philosophy of the exchange need not detain us; enough that I had almost as much fun before as during the debâcle. But after one or two engagements, I cast about for a way of saving some of the long hours of carpentry and a method soon came to hand. Heretofore, I had constructed each vessel as a separate unit, lovingly sawing and carving every smokestack, pilot house and mast for its appointed place. Now I standardized the fleet—dreadnaughts to be 18 inches long, cruisers 12, monitors 10, destroyers 8. I piled four boards together, ruled a pencil form on the top one, and cut four hulls at a sawing. Smoke stacks and gun turrets were required in quantity by all craft; and these I sawed by the dozen from old broomsticks and round poles. Deck-houses like hulls were done in job lots. A day or two of steady work, and my workroom was littered with standard parts. The hulls were placed in rows, and the parts set upon them. Then with a hammer and a mouthful of nails, the task of assembly could be vigorously pushed forward. Instead of weeks, a fleet of equal tonnage was ready for destruction in three days. But I have to confess that they did not make quite so brave a showing.

Today as I plow through volume after volume by the learned exponents of modern industry, I am convinced that, quite unaided, and despite his tender years, that scrubby-handed boy had discovered and applied the principles of mass production. While Henry Ford gets all the kudos. Also I suspect, despite the tumult and the shouting, that all workers in wood and metal possessed of common sense, from the Cro-Magnon man onward, have similarly, and frequently, invented and employed the technique. The modern pæans are understandable in respect to the scale of operations, but hardly in respect to basic principles. Ptah-hotep knew all about them. Therefore when the guest of honour at the next banquet you attend, says, as he is sure to: . . . "the American genius, which gave mass production to the world," remember that it is a pretty old world.

Mass production is not sheer bigness; it has nothing to do with financial consolidation; it is not concerned with high speed or great volume, as such. It means, in essence, just two things:

The making of standard interchangeable parts.

The assembling of these parts into the completed unit, with a minimum of handicraft labor.

A possible exception is to be found in the meat-packing and lumber industries, where the process is reversed, and a completed unit—the steer or the tree—is disassembled; broken down into standard cuts of beef, or shingles. As steers and trees are living organisms, no two, alas, alike, the doctrine of fineness of measurement and interchangeability cannot strictly apply, and thus the process, while it may look like mass production upside down, is only a brother and possibly an illegitimate one.

Various important corollaries today follow upon these two basic principles. They include:

Careful preplanning of the standard design.
A highly developed art of measurement.
Tools capable of working to very small tolerances (allowances of error) so that interchangeable parts can really interchange.
A continuous flow of parts through the assembly system.
A continual emphasis on the automatic function—the fewer human hands touch the process, the better.

When you take a little factory of watch makers, and convert it into an enormous factory with all manner of helpful power tools, but leave the basic process of hand-fabrication unchanged, you have not moved an inch in the direction of mass production. The old trusts of the 'nineties, when they gobbled up all the steel mills or oil refineries on the horizon, and operated them from one control on lower Broadway, similarly did not move an inch. Mass production is an engineering, not a financial, phenomenon. It means a revolution in the shop, the stamping out of handicraft, and, nowadays, micrometers, turret lathes, milling machines and assembly belts.

When the King's armourer was hammering out upon his forge the 90-pound coat of mail for Henry VIII, he had to do some rather nice measuring, and do it in advance. Otherwise the bally thing would never go together. But in that he himself put it together, he could chance a certain amount of error; by touch and eye he could see that the parts fitted as he went along. Similarly all good craftsmen down the ages—locksmiths, boat builders, cabinetmakers—measured, and backed their measurements with trial and error.

After Watt the situation began to change. The first effect of the steam engine was greatly to increase the sheer output of commodities—say yards of cloth, or dozens of kettles—without changing drastically the function of the worker. He had a power tool rather than a hand tool, and he could do more with it. He continued to "mate" parts by putting them back in the lathe or the drill and scraping them down to size, or by making the hole bigger. He continued to be essentially a craftsman.

Then came the beginning of mass production to change his status altogether. Shape-giving operations were subdivided among a number of men, each turning a little, or drilling a little. The separate parts which each produced were piled up in storage awaiting assembly. Sometimes enormous inventories of finished and partly finished units were accumulated.

Next "continuous flow production" was born of the necessity to straighten out the assembly problem. Under its rules the parts never get into the inventory bins at all, but start to move the minute they are completed—preferably on a conveyor belt—towards the central assembly point. If the completed part is say the frame of a Ford car, it moves steadily down the main aisle, gathering up the other parts which feed in from either side, and bolting them home as it goes. This saves time, interest on working capital, and skilled labour. Bolters are cheaper than trial and error hand-fitters. Also the whole process will drastically increase output, precisely as I proved with my battleships.

If trial and error fitting was to be given up, something had to take its place. The machine tool moved into the gap. It is the machine which makes machines, and its importance in the industrial revolution, particularly in the development of mass production, is enormous. "Upon these tools depends the construction of all other kinds of machinery, and the size and accuracy of all modern machinery depend upon the size and accuracy of the machine tools available for their construction." Henry Ford has about 25,000 of them at Highland Park, divided into 250 classes. American inventors have made great contributions to this art, especially:

The milling machine
The turret lathe
The automatic lathe
The grinding machine

The first was invented by Eli Whitney, and the original model stands in Yale University. The next two were invented by men of Hartford. The three together do much to confirm Mark Twain's judgment in selecting his Yankee from Connecticut. Whitney's machine could be carried around on a man's shoulders, but the General Electric Company today has a boring mill that will carve a hole through a chunk of steel sixty feet in diameter.

Meanwhile accuracy has been attained in two directions. Instead of cutting by the lathe or planer, the present practice is to bring the surface to size by grinding it with a grinding machine, thus insuring a far snugger fit. Secondly, measuring instruments have become almost diabolic in their march towards nothing at all. The micrometer was invented by a Frenchman. Brown and Sharpe of Providence presently produced one which would measure to $\frac{1}{100,000}$ of an inch. Today, standard reference gauges, using the principle of the length of light waves, are accurate to $\frac{1}{1,000,000}$ of an inch! (Such are, however, used in laboratory work primarily.) Against such devices for controlling machine tools, hand-fitting is a bull in a China shop—totally unable to compete. The interchangeable parts for mass production can thus be turned out to an accuracy of astronomical minuteness, by machines built like a bull rhinoceros. Finally, the whole process, save setting the original gauges, is removed from human interference, and made as self-regulating and automatic as possible, with the ideal of a one-hundred per cent automatic performance always before the man at the drawing board. Human fingers are too gross and clumsy to fumble with this combination of incredible delicacy and roaring power.

You get the picture. A great glass-domed space, flanked with battalions of humped and gleaming tool machines, taking bars and billets of raw steel, shaping them, bending them, boring them, grinding them; delivering unit parts to a conveyor which bears them to a main assembly belt where they are locked together—men sometimes assisting—and then into the shipping room—so many completed articles to the minute, no more, no less, a steady stream of motor cars, radios, bicycles, typewriters, clocks, tractors—what you will.

The Krupp Works today covers five square miles of floor space. It takes three days to see it all. Ninety-foot plates of steel are rolled out like chewing gum. A 4,000-ton press picks up a log of steel as though it were a lead pencil, holds it by the throat, and sinks a hammer twelve inches into its glowing mass, squeezing out a gush of molten metal like water from a wet rag. In the final assembly rooms are acres of locomotives in dignified rows: "Diesel engines towering like a procession of elephants with howdahs on their backs, textile machinery sprouting before your eyes like Ford cars; a sea of dynamos, motors, turbines, harvesters, cash registers, motion picture projectors, automatic weighers and mixers, as far as the eye can see."

Standard parts for mass production were employed by Sir Samuel Bentham in building ships for Catherine of Russia on the Black Sea in 1787. The Dutch used the process even earlier. Eli Whitney introduced the technique in America when he manufactured muskets for the government in the War of 1812. He was forced by lack of skilled hand workers "to substitute correct and effective operations of machinery for that skill of the artist which is acquired only by long experience; a species of skill not possessed in this country to any appreciable extent." Here we have a case of the machine not displacing the skilled workman—whom Whitney rightly called an artist—but holding the fort in his absence.

Isolated cases can be picked out in various countries as the industrial revolution gathered its forces through the Nineteenth Century. Meanwhile Messrs. Brown and Sharpe and the rest were refining the gauges and perfecting the machine tools to make the process possible on a really gigantic scale. America is chronically daft about something, and many can remember when we lost our wits about the bicycle. In 1896 there were four million pedallers upon the roads. To meet the great demand, Colonel Pope and his fellow manufacturers had to do something drastic. They found that they could best keep up with their salesmen by devising special machines for spokes, rims, tires, handle bars, saddles, and then assembling in one place the separate parts. In another decade, we began to go motor mad. The technique was taken over bodily and, because a motor is a far more complicated thing than a bicycle, vastly amended and improved. Then the process spread to typewriters, radios, tractors—all manner of things.

In 1929 airplanes are built in small factories by skilled workmen. While plenty of power is available to help them, there is a great deal of hand fitting and adjustment. When a "ship" is launched, the entire working force assembles, and with pride and joy watches the first flight of the winged creature on which so much individual care and attention has been lavished. Not disembodied standard parts have been fabricated, but a living unity, with a character of its own. So Donald MacKay and his workmen built the *Lightning* and the *Flying Cloud.* But the clipper ship was ever a dangerous beauty with her incredible spread of canvas; and so is a modern airplane. The former was overwhelmed by steam, before she could be standardized—for which mercy the artist will thank whatever gods may be. The latter is still in the experiment stage, fickle, and far from fool proof. In a few more years, perhaps even before these words are printed, a standard, reasonably safe design will have been evolved. The little aircraft shops will disappear; out on the streets will go most of their skilled mechanics; great walls of cement and glass will rise; battalions of lathes and grinders will spew out their millions of interchangeable parts; the assembly line will begin to march; and gone forever will be the individual ship and the loving care that followed and took pride in her.

There is a certain sadness in all this, but it does not behoove us to grow maudlin. We may weep for the spirit of craftsmanship here crucified, but we can only rejoice at the arrival of a stout, inexpensive plane, which millions of us may use without dropping to death in a tail spin. Furthermore, while a standardized clipper might have lost her beauty due to the limitations of her design and the medium in which she was worked, a standardized airplane need send no hostages to loveliness. Her design and her medium call for the micrometer and the superlative finish of the grinding tool. These can if they choose deliver a more just and lovely thing than craftsmanship could ever achieve.

Mass production crystallizes years of experiment, and trial and error, into one standard design. The design is then executed by the most intensive preparation of dies, castings, and special machine tools, involving literally acres of paper work. But when the power is turned on, experimentation must cease. Otherwise continuous flow is thrown out of step, the myriad of standard movements upset, and the whole tremendous investment threatened. The cogs must all articulate or the vast monster becomes as helpless as a blinded dinosaur. It cost Henry Ford a cool hundred million to change from Model T to Model A. More than fifty per cent of all his production machinery had to be replaced, redesigned or supplemented. To produce two gears in the new rear axle, 43,000 machine tools had to be altered, and 4,500 brand-new ones built. The dies which replaced the old ones alone cost $5,000,000. "Everyone who has worked on a drawing board knows the havoc that is caused all the way down the line by the mere shifting of the center of a hole in a casting; the endless amount of detail, the innumerable changes that have to be made in tracings, blue prints, patterns, dies, moulds; not to mention the effect upon the organization as a whole. . . ."

If the design is good for years to come, mass production is the cheapest way to give the product to the world, and for many articles, the way which promises the best in quality. But if the design is dubious, or likely to be rapidly superseded by better designs, mass production may act as a brake on technical progress; a morass into which creative invention stumbles and sinks. Ford could afford his hundred million dollar shift, but what the richest man on earth can do, few can emulate. More cautious corporations do not tend to change their methods, endangering dividends, until they must. This is the reason why many brilliant inventions are purchased by great companies only to be put on the shelf. Mass production has dug their graves. This is the reason too why Mr. Siegfried warns us that Europe, with her more flexible system of production, may, like David with his slingshot, conquer us in the end.

Factory machines have progressed through three chief stages. (Though any given factory today may still remain in the earlier stages.)

> First, they supplied more power to the skilled worker. They increased his output but left his job substantially unchanged.
>
> Second, they subdivided the manufacturing process, allowing unskilled or semi-skilled workers to feed them, remove the output, and carry on the few repetitive motions which their tending required. This is the robot stage.
>
> Third, they replaced the unskilled worker with their own steel fingers, doing the feeding, processing, packaging, themselves. The skilled man comes back into the picture as inspector, repairer, adjuster of delicate controls. His job is interesting, non-repetitive; requires intelligence. The robot has largely disappeared.

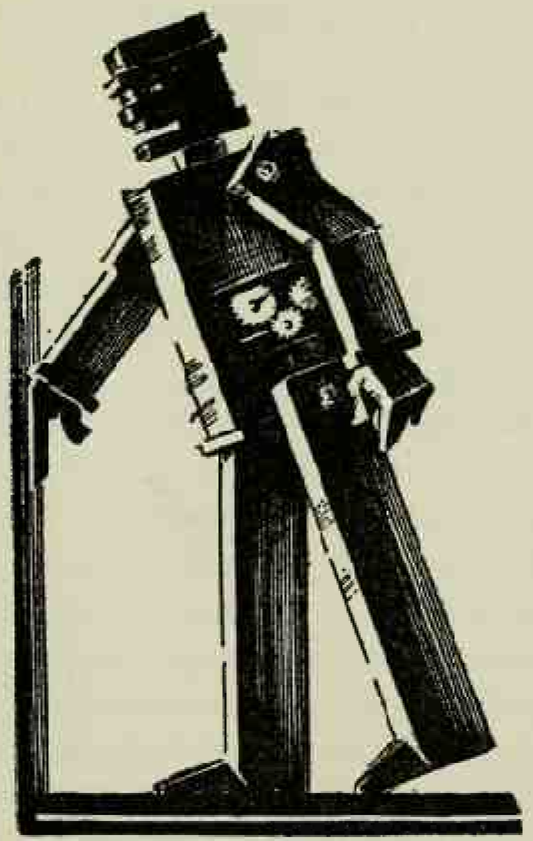
A new automatic plant for making automobile frames is 600 feet long and 212 feet wide. Raw materials in the form of steel strips go through a combination straightening and inspecting machine, and are then sent by monorail conveyor to the pickling department where they are chemically treated. They then stop at nineteen stations on the main assembly line where machines proceed to pin and rivet brackets into place. The frame is then automatically put together; and descends by gravity discharge to a painting machine, whose baking enamel flows at the rate of 750 gallons a minute. It takes an hour and fifty minutes to complete a frame, and ninety per cent of the time the units are on conveyors, moving. The plant operates day and night, seven days a week—and can only pay its way if the output reaches 75,000 frames yearly. No human hands are needed in the actual working process. Viewed from the outside, the plant and its machines are making motor car frames absolutely unassisted. One hundred per cent automatic performance has been substantially achieved.

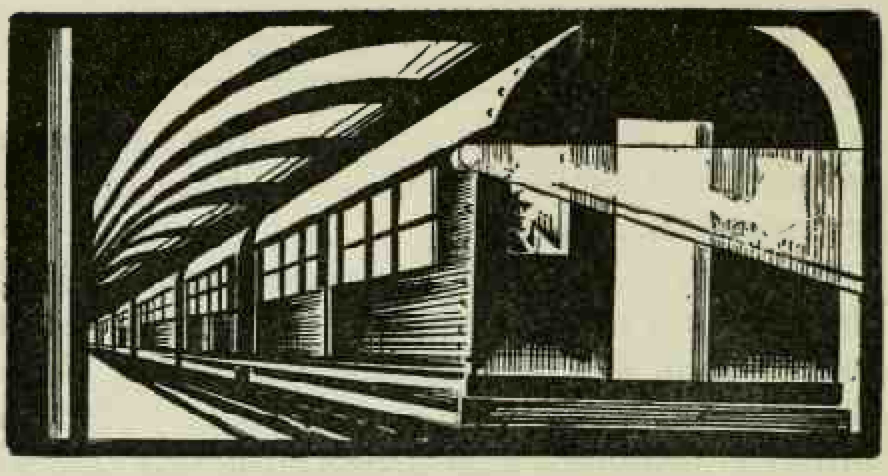
Industry does not leap, of course, from hand tending to the completely automatic. There are all manner of semi-automatic stages in between. If a given process has twenty operations, the automatic curve may begin with only one of them; then spread to four, five, a dozen operations. Only recently has the full cycle been achieved in a few processes. But more and more are coming into line. The tendency is all about us. We see it in such developments as:

Automatic railroad switch yards
Dial telephones
The talking movies
Manless elevators
Automatic steel making
Automatic sugar mills and soap factories
Mechanical stokers
House oil-burning furnaces with thermostat control
Electrically controlled battleships
The "foolproof" movement—such as railroad block signals—where the human nervous system is relieved of responsibility for operation and control. Automatic ship bulkheads are capable of preventing such disasters as overwhelmed the *Vestris*—provided owners are willing to pay for them.

The other day I watched a rectangular figure, fashioned like a cubist's nightmare, raise its arm when whistled to through a telephone. As the arm came up, a mechanical piano began to play, a fan revolve, a washing machine bubble; while dial lights snapped on and off in the general region of his stomach. It was no other than Mr. Televox, the product of the Westinghouse laboratories, representing a late development in the automatic process. He will displace the skilled watcher of dials in power houses. The New York Edison Company recently opened an electrical distributing station to be operated without a human being within its walls. Mr. Televox will be the only resident, requiring neither food, rest, nor sleep. He will be telephoned to from time to time by a living man, three miles away, and according to the orders spoken or whistled, will break circuits, move levers, stop and start machines.

The ghost of James Watt must have shuddered down the years—for he was a kindly man—as the bodies of women, men, and little children were broken in the dismal caverns where his engines pounded . . . but for Mr. Televox his back must straighten, and his hand go gladly to the salute.





CHAPTER VI

THE WALL OF STEEL

We have looked into the anatomy of machines; we have briefly traced their development from the valley of the Nile to the valley of the Ruhr. Our main concern, however, is not with their technology or history, but with their impact upon the day-by-day life of human beings. That impact is both direct and indirect. On the one hand, we are influenced by the machines that we see, hear, touch, use and operate; on the other, by the new commodities, services, laws, folkways, standards, philosophies, arts—which machinery has engendered. The second is probably more important than the first, but as many of the lamentations of the gloomy prophets center around robots and machine slaves, the direct impact needs careful consideration. This chapter attempts to summarize some of the direct effects of machinery on the people of the Western world today, particularly in the United States, and thus takes up the personal story with which the book began, and carries it further. You will remember that I doubted if machinery was enslaving me, doubted if it directly subjected the mass of my fellow citizens.

The common machines

Not counting simple tools, it is probable that there are more machines in the United States than there are people. The aggregate of motor cars, telephones, and plumbing systems alone, would start the list with about sixty million mechanisms, or the equivalent of half the population. The varieties are countless beyond description, running all the way from watches no bigger than a ten-cent piece, to a 200,000 horsepower turbine. The gross direct impact is of course the sum total of all existing mechanisms in all their variations. This leads us into regions beyond the possibilities of exposition, but fortunately such detail is hardly necessary to our purpose. Better than ninety per cent of all direct effects flows from less than one hundred varieties of mechanisms. In the following table they are listed. The accent here is not technical importance or power-generating capacity, but sheer quantity. These, so far as I can estimate, are the machines which we chiefly use, operate, or submit ourselves to; the mechanisms which directly affect the behaviour of the most people. The power plant at Niagara Falls has vast, far-reaching, indirect radiations, but only a handful of men are needed to operate the great turbines. The direct effect is accordingly negligible. A radio set is little more than a toy, the power it uses is minute, but some thirty million people in the United States are seated before it every evening. Its direct effect, due to sheer quantity, is thus enormous. On such considerations is the table constructed. An attempt is made to classify by occupations, and wherever possible estimates of total quantity are given. The machines of the first classification—those which affect us as citizens rather than specialists—are not repeated, though one or more of them belong in every subsequent class.

THE COMMON MACHINES OF AMERICA

Those which affect us generally

Clocks and watches	100,000,000 (at least)
Automobiles, buses and trucks	25,000,000
Locomotives	70,000
Trolley cars	500,000
Steamships, ferries and motor boats	....
Telephones	18,000,000
Pianos	10,000,000
Radios	10,000,000
Victrolas	12,000,000
Electric lights	....
Dentist drills	150,000
Slot machines	....
Voting machines	....
Electric bells and buzzers	....
Filling station pumps	....

Housewives

Plumbing installations	15,000,000
Gas, oil and electrical ranges	10,000,000
Central heating systems	10,000,000
Sewing machines	10,000,000
Electric irons	8,000,000
Vacuum cleaners	5,000,000
Washing machines	2,000,000
Mechanical refrigerators	1,000,000

Farmers

Tractors	600,000
Pumping systems, windmills	
Plows	
Harvesters	
Harrows	
Cultivators	
Mowers	
Spraying machines	
Threshing machines	
Cream separators	
Guns	

Factory workers

Assembly belts
Lathes—all kinds
Looms and spinners—all kinds
Printing presses
Punches and shapers
Planers and grinders
Electric furnaces
Milling machines

Construction workers and miners

Drills
Coal-cutting machines

Construction workers and miners—Continued
- Derricks and cranes
- Steam shovels
- Piledrivers
- Swampers
- Crushers
- Riveters
- Pumps
- Cement mixers
- Steam rollers
- Blasting mechanisms
- Stationary steam and gas engines

Transportation workers, including garage men
- Safety signals
- Travelling cranes
- Track repairing devices
- Baggage handling devices

Office and store workers
- Elevators
- Subway trains
- Typewriters
- Adding machines
- Cash registers
- Bookkeeping machines
- Mimeographs and addressographs

Professional and military men
- Instruments of precision—stethoscopes, thermometers, X-ray machines, transits, microscopes, etc.
- Battleships, submarines
- Artillery, rifles
- Airplanes
- Tanks

These seventy odd machines, or machine clusters, are those which chiefly affect us as behaving organisms. We are, depending upon our jobs, continually seeing them, hearing them, smelling them, touching them, feeling them, steering them, riding upon them, oiling them, feeding them, and generally bumping into them. In the course of a year, about 50,000 of us are killed in the process of bumping, and some millions of us injured, but at the same time they save us an incalculable number of steps, and an incalculable amount of dull, hard work. Generally speaking, these same machines dominate all Western civilization. They are now proliferating in Japan; expanding in Russia, Turkey, even in China.

While it is impossible to count all the common machines, the list itself, including the items which can be counted, makes it evident that a tremendous mass of metal is forever around us. A wall, which grows higher every day. But that it imprisons the majority of us tightly is not even open to question. It certainly does not, and cannot, for decades to come. It is far too low a wall not to be readily jumped over. If my direct contact with machinery does not exceed two hours a day, the average for all my fellow countrymen is probably even less. For children and housewives it is most certainly less. For farmers, storekeepers, office workers (except typists and calculating machine operators), professional workers, and the bulk of unskilled construction and transportation workers, it is presumably about the same; leaving a higher ratio only in the case of factory employees, and certain groups, largely skilled, among the transportation, mine, and construction workers. If I am not psychologically undone by contact with my quota, it stands to reason that most people will not be undone. The evil effect, if any, must come in that relatively small fraction of the population which confronts machinery for two, five, eight hours a day—textile operatives, men on the assembly belt, locomotive firemen, taxicab drivers, derrickmen, steel workers. For the rest of us, contacts are casual and temporary. We are bound to no rigorous machine rhythm; we use a device as it serves our turn, only to drop it again.

Varieties of contact

At this point, it is necessary to probe deeper into the meaning of direct contact. I go from Times Square to Yonkers, in one case in the subway, in the other driving my own car. In both cases I am in direct contact with a machine, employing it over an identical area for transportation purposes. Are the physiological effects the same? Indeed they are not. On the one hand I submit to bad air, an ugly environment, and control by somebody else. My role is entirely passive. In the second case, I dominate my own mechanism, guide it through complicated traffic patterns, speed it up along the fine vistas of Riverside Drive; slow it to a walk when occasion warrants. My role is active and psychologically stimulating.

To say that one confronts a machine is to say something but not very much. The kind of behaviour which results from the contact is a far more important consideration, and as an instant's thought will disclose, all manner of reactions are possible. Despite the diversity, it is possible to reduce these reactions to seven basic classes.

1. Operating machines with a large measure of individual responsibility in guidance and control. (Running a motor car, an airplane, or a locomotive.)
2. Operating stationary machines with responsibility only for speed or direction control. (Running a turret lathe; controlling the engines of an ocean liner; operating a vacuum cleaner, or an adding machine.)
3. Tending machines with no responsibility for control. (Feeding a punch; mending yarn on a loom; tightening bolts on an assembly line.)
4. Inventing, designing, repairing and inspecting machines. (The work of the planning and inspecting staffs of any large factory—say Ford's. The day-by-day work of a good garage man.)
5. Playing with machines. (A child with an electric train; his father building a radio. Playing the saxophone, trap-shooting.)
6. Being carried by a machine with no responsibility for its control. (Riding in an elevator, a train, steamship, or a Ferris wheel.)
7. Submitting to a machine process in someone else's control—a variation of point 6. (Sitting in a dentist's

chair; facing an enemy's barrage; crossing a traffic-laden street.)

We touch here the roots of the whole problem of machinery and man. Only to read the above makes it obvious that certain machine contacts are as lethal as others are wholesome and invigorating. To make simple, sweeping conclusions about anything so varied in scope is downright nonsense.

The fact of operating a powerful machine with full responsibility for its control, far from being a monotonous, depressing, soul-destroying job, is, as a rule, precisely the opposite. It tends to expand the ego, establish self-confidence, break down inhibitions, keep one out of a rut. One needs no further proof than the health records, both mental and physical, of locomotive engineers as a group. A finer, more courageous, better-balanced body of men is not to be found in this or any other civilization. Indeed no more proof is needed than one's own reactions to driving a motor car, if the runs are not interminably long or over-complicated.

The same applies, but with diminished force, to the operation of machines whose movements are limited. Here control is not complete, but responsibility for a powerful monster is still marked. The builder of the Mohawk Trail told me that every man who came on the job wanted to run a pneumatic rock drill—to the observer a dusty, noisy, devilish device. Engineers on steamships, skilled machinists, are not normally broken and ailing men, but the reverse. The case is far more dubious with elevator operators.

When we descend to plain machine-tending, however, the story changes—particularly when the machine sets a remorseless rhythm to which the worker must adapt himself. In Chapter VIII these changes will be described in some detail. Here we can only observe, that without responsibility, without the possibility of letting something of the power of the machine into one's own veins, the process has the chance of becoming very monotonous, fatiguing, and even mentally dangerous, while the chances for physical accidents markedly increase.

In respect to inventing, inspecting and repairing machines we have a skilled, often a very highly skilled occupation, where routine tends to be at a minimum, and one's creative or observing faculties at a maximum. It is replete with change of pace, and in many cases is as exciting as controlling a motor bus or a locomotive.

In playing with machines we are subject to no threat of monotony, because, by definition, when play becomes burdensome, it ceases to be play. Machine recreation can hardly develop serious neuroses or inhibitions, but it can unfortunately hold the spirit of play to very low levels. Some machines, as we shall see, help us to play better, but others—perhaps the bulk of them now operating in this field—tend to make us into second-hand watchers and listeners rather than into active participants.

Finally, in respect to submitting to machines—either to be carried upon their backs, or to feel their steel tongues and fingers upon our bodies—here again no sweeping generalizations are permissible. To cross the ocean in a great liner is a stimulating experience, to cross it in a Zeppelin is even more so; to ride for five miles in a New York subway at six o'clock at night is a dreadful experience. Certainly there is nothing degrading or harmful per se in submitting to the ministrations of a machine. How many souls has the pulmotor brought back from the further shore? And so far as degradation is concerned, I, for one, would rather be carried by the turbines of the *Leviathan* than by four score of galley slaves, handcuffed to their oars. . . . But when we stumble, as we must in this last category, upon mechanized warfare, we touch a buzz saw of the first dimension.

Machine-made habits

Another approach to the problem is a consideration of the direct effects of machinery on traditional habits. One hundred and thirty years ago when my great-great-grandfather was living in the town of Newburyport, Massachusetts, there was hardly a steam engine in all New England. The people of Newburyport were concerned with eating, sleeping, mating, working, even as are the people of the town where I now live. What has the machine done directly to change those basic functions?

In respect to eating, we still sit at table and consume much the same sort of foods with the same implements. By virtue of machinery we have the priceless boon of the tin can, which gives us a greater variety of softer and less succulent material, but the process of eating itself is little changed. No machines grace the table, save an occasional electric toaster or coffee percolator; courses do not come smoking from the kitchen on endless belts; no automatic stokers displace knives and forks; and despite much talk at the annual conventions of learned chemical societies (moderately ridiculous talk it is), no synthetic laboratory mixtures have yet appeared in any quantity to atrophy the muscles of our jaws.

In public eating places the change is more marked. The cafeteria, the automat, and the soda fountain, all exhibit the impact of the machine. In the modern soda fountain, we have a double line of nickeled mechanisms tended by white-robed specialists of a very pretty skill; and what amounts to a whole new set of high-speed eating and drinking habits on the part of its clientele. The phenomenon has been very competently analyzed by Mr. Charles Merz, to whom the curious reader seeking further information is referred.

The machine has not been able to do much with sleep—save possibly to render it more fitful. We use the same old beds; and what we gain in steel springs initially, is lost as age overtakes them and they falter in their middle parts. For the copper warmer, an electric pad is substituted, while on sultry nights a motor-driven fan may manufacture a draught to rival the harbour breeze of Newburyport in 1800. Meanwhile, it is safe to say that for every person lulled to slumber by the radio, three more are given a longer period in which to lie staring at the ceiling, contemplating their day's transgressions. A new method has been invented to inculcate foreign languages by feeding the patient's subconscious process while he sleeps by means of earphones attached to a victrola—but I do not hope much from it.

In respect to mating, we have matriculated from park benches to parked motors; we have speeded up the exchange of tender nothings by virtue of standardized telegrams; flowers, it is alleged, may be wired to any part of the planet; honeymoons cover more geographical area (though Niagara Falls and Atlantic City still stoutly hold their own) ; there is rumour of a new contraceptive, whose spermatocidal function depends upon the generation of an electric current. Ladies who slept in the minor agony of curl papers night after night, can now get it over with in the one great agony of a permanent wave—conducted by a sinister machine which looks like nothing so much as a device for wholesale electrocution.

The telephone, particularly on party lines, has done much to extend the area of gossip. Entertaining is still entertaining, and parties, parties; though new machines have stepped into the place of old machines in furnishing the music. Children still go to school houses as they did in Newburyport, and sit at desks in front of blackboards, globes, and nervously exhausted teachers. The schools are larger and better ventilated, the rattan (worked on the lever principle), has disappeared, pedagogic methods are greatly changed, but save for a few moving pictures and typewriters, there are no more machines in the educational process than there ever were.

We go to church (in diminishing numbers it is true) in a motor, rather than a horse and buggy; the organ is furnished wind by a motor instead of by a perspiring organ boy; sermons by radio are multiplying; the parson has an adding machine in his sanctum, or wishes he were in a position to have one—but by and large it is the same religion, accompanied by the same hymns, nor have we, in a century and a half of machinery, caught up with the Buddhists and invented a praying wheel. If we had really cared about speeding up religion we might have had a turbine.

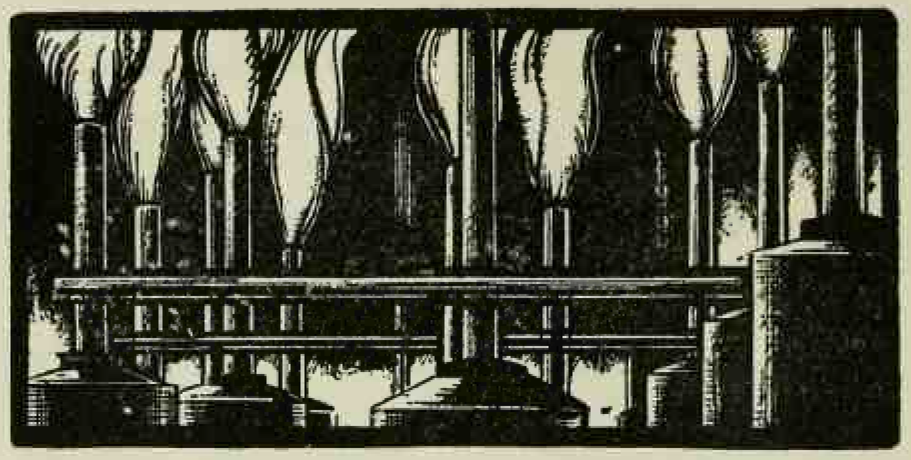
Two great habit complexes remain in which drastic changes have occurred; changes which would boggle the eyes of the good burghers of Newburyport. I refer, of course, to work habits and play habits. My great-great-grandfather could make something of the work of masons and carpenters building a modern house, but the Chevrolet factory would paralyze him; while an evening at a motor-fed roadside jazz house would inexpressibly shock him, even as slow movies of a high diver would delight him. In these two departments, the machine has engendered something in the way of a real revolution; here its impact has been most pronounced.

Mr. and Mrs. Lynd in *Middletown* note the following sequence in the rapidity with which habits have been changed in the last generation. Their study is undoubtedly the most authoritative ever made of a Power Age community.

1. Work habits (the greatest change)
2. Play habits (also very great)
3. Educational activities
4. Community activities—clubs, social work, etc.
5. Home-making habits
6. Religious habits (the least change)

The phenomenon of the direct impact should not be left without a word or two concerning noise and smoke. Some scientists believe that the Western world is slowly going deaf because of the cacophony which day and night assaults its ears; a concert in which chief place is assigned—after careful study with an instrument which measures sound—to the motor truck. Most street accidents are the results of nerves unstrung by noise. London, because of its smoke—we have a smoke measurer too—loses fifty per cent of the sunlight, and practically all of the ultra-violet radiation which is its natural due. Pittsburgh, which long held the grime championship of the United States, has lately given way to St. Louis. Boston, which burns anthracite, has only 5,360 dust particles per cubic foot against 17,600 in St. Louis.

Yet when all is said and done, we must remember that two hours a day of direct contact, which is my personal average, is still probably a maximum for the wayfaring man of the Western world. And above all we must remember that even for those minority groups—particularly factory and transportation workers—whose average contact is much higher, the fact of confronting a machine may mean exaltation and delight, even as it may mean degradation and despair.



CHAPTER VII

UNDER THE LIFTING SMOKE

"MACHINERY has done the work. Machinery has left them in rags without any wages at all. Machinery has crowded them into cellars, has forced them from their country to seek in other lands the bread denied them here." So wrote the editor of the *Potter's Examiner* in the England of 1844. Were I to tell you the complete story of how machinery came to England and what it did to the three generations following Watt, you could not stand it. Caligula himself could hardly have stood it. It is a record of social debasement, cruelty and black despair, without parallel in history. A slave owner came to watch the little children at their work in the mills, and his words have come down to us: "I have always thought myself disgraced by being the owner of slaves, but we never in the West Indies thought it possible for human beings to be so cruel. . . ."

Authorities differ as to the extent of well-being in pre-machine England—it seems to have declined somewhat just before the industrial revolution—but all agree that there was enough to eat, always a place to lay one's head, a fair degree of economic freedom, and relatively little unemployment, except in the locality where the Enclosure Acts were being enforced. As to the artistry of the period, one only needs to walk through English villages today, and compare the new with the old. Mankind has seldom sheltered itself more beautifully. The songs and carols of the time have come down to us; the Maypole dances, the village festivals—all bespeak a reasonably happy folk; dirty, illiterate, crude, if you please, but hearty, and, by virtue of their cottage crafts, relatively independent. "There is reason to suppose," say the Webbs, "that the England of the yeoman cultivator and the master craftsman, with all its privations and all its drawbacks, yielded to an actual majority of its inhabitants, more food, more serviceable clothing, more light, purer air, pleasanter surroundings—than did the far more productive England of the first half of the Nineteenth Century."

These villagers, furthermore, because of the "putting out" system, were already, by 1750, working into the industrial structure. A "factor" would leave raw wool for them to spin in their spare time at home. The completed yarn he would pay for, and then take it to the cottage of a family which had a loom, and contract for the finished cloth. When the factor persuaded a number of cottagers to come and work in his own central shop, it became, naturally enough, a "factory."

There were "factories" in Egypt and Mesopotamia. The factory system as such is not a machine system, but a legal system, whereby the building, the raw materials, and the tools are owned by the factor, or capitalist; the worker contributing nothing but his labour. This normally makes for more efficient production than cottage industry, but few have claimed that it made for greater happiness or independence. The time-clock displaces one's own sweet will. Before Watt, factories were few and small, and the discomfort which they caused was at a minimum; after 1776, they began to engulf an increasing percentage of the population.

When the first steam engines appeared, all the inhabitants of these charming cottages did not turn suddenly into grimy machine-tenders. Far from it. Perhaps up to the time of his death, Watt could look over England and rejoice at the good which his engines had brought. The new factories gave jobs to those who were still suffering from the Enclosure Acts. So greatly did they lower costs that demand for British textiles increased briskly, making for more and more employment at fairly good wages. It is recorded that workers began "to indulge upon many occasions with the wheaten loaf."

The farmers descended upon the new factory towns in swarms. The demand for labour at Bolton was so great that the population more than doubled in a decade, and popular opposition to the use of machines, as a means for eliminating labour, ceased. The little village of Lancashire expanded into a metropolis. Prices were lowered, more money was circulated, more commodities were available than ever the common man had known before.

Alas, after a red sky at morning, the clouds began to gather. There was no conscious attempt to adjust the worker to the exigencies of his new task; the town to the pressure of its new population. Properly guided, the early advantage might have been held, but the very forces which made the industrial revolution possible, expressly stipulated that they would brook no interference from God, nor state, nor man, in the unhindered pursuit of their personal advantage. Had not Adam Smith, himself, assured them that an "invisible hand" reached forth and so arranged terrestrial affairs that the minimum of social interference automatically insured the maximum of social good?

Two hundred thousand people herded into Manchester, without a single public park or playground. Great fortunes were made in South Wales but the workers had to go a mile for water, waiting in queues a great part of the night with their buckets; for the chief town of this rich district had neither a public water supply, a lighting nor a drainage system. The Romans, with no facilities for making cheap iron pipes, or iron pipes at all, supplied their towns with pure water, but the people of Wales had to drink whatever the river brought them. The death rate in this district increased threefold.

Nowhere was provision made for parks, theatres, or recreation of any kind. There were no schools except the Sunday Schools set up by a few benign manufacturers, like Robert Peel. From a fragrant and lovely countryside, industrial districts changed to bleak and dour ugliness; unplanned, chaotic and foul. Speculative building ran riot, herding the new population into houses as fragile as they were ugly. Whole families were packed into one small room. Tuberculosis, deformities, idiocy, grew by leaps and bounds. Epidemics became chronic. "A low, putrid fever of a contagious nature has prevailed among the poor for many months in the cotton mills of Radcliffe."

The factories likewise were run up by the jerry builders; with low ceilings, narrow windows, no adequate ventilation. Two-thirds of their forces were women and children, who could mind machines as well as men, and were far, far cheaper. The workers were without restrooms, decent toilets, or safety devices of any kind. Fatal accidents and maiming injuries were "frightfully common"; nor were damages ever paid to the families of the victims. The doctrine of the negligence of the "fellow servant" saw to that. Meanwhile "every man's factory is his harem"; women workers had to prostitute themselves to hold their jobs. Illegitimacy increased beyond anything known before. A new spinning machine was introduced with thanksgiving because "by its means a child of three or four years may do as much as a child of seven or eight on the old engine."

Conditions in the mines were worse if possible than in the factories. Women worked underground for twelve to sixteen hours a day, hauling loaded coal cars on their hands and knees, harnessed like animals. Children of four and five were the "trappers" who opened the doors from cave to dripping cave to let them pass. Undersized children were stolen for chimney sweeps, only to be burned to death, lost inside flues, smothered in the ashen dark. For years they might remain unwashed—if they lived so long—and food was thrown to them like dogs. The tar in which they worked led continually to cancer.

Nobody could argue that a peasant or a journeyman before 1750 was a freeman, but he was infinitely more free, and infinitely more of a human being, than his grandchildren in the mills and mines of 1830. Life was more versatile and interesting when craftsmanship was combined with agriculture. For many occupations in the new system only one set of muscles and one part of the mind was used, and that a low one; other faculties remained idle and undeveloped. Nor were there any schools or playgrounds to right the outraged balance. The Greeks and Romans built immortal public buildings and made provision for public amusements. Manchester was very different.

J. L. and Barbara Hammond have summarized the era in a classic paragraph:

> Thus England asked for profits and received profits. Everything turned to profit. The towns had their profitable dirt, their profitable smoke, their profitable slums, their profitable disorder, their profitable ignorance, their profitable despair. The curse of Midas was on this society; on its corporate life, on its common mind, on the decisive and impatient step it had taken from the peasant to the industrial age. For the new town was not a home where man could find beauty, happiness, leisure, learning, religion, the influences that civilize outlook and habit, but a bare and desolate place, without colour, air or laughter, where man, woman and child worked, ate and slept. This was to be the lot of the mass of mankind: this the sullen rhythm of their lives.

With this nightmare all about him, is it to be wondered that Samuel Butler, in cold ferocity, wrote *Erewhon?* Or Charles Dickens, *Hard Times;* Zola, *Germinal;* Marx, *Das Kapital?* If, in 1850, a balance had been struck between the gains and losses of machinery, no sane man would have been in doubt as to the result. Even the fence rail would have been bare of any philosopher worth the name.

On the one side, the loss of economic independence; miserable wages; unemployment; hideously long hours; monotonies, fatigues and repressions on an unprecedented scale; new diseases, epidemics, accidents, a mounting death rate; the employment and destruction—physical and moral—of women and little children; slums, barracks, cellars, noise, dirt, smoke, a devastating ugliness in working place and living place; the play and education of the village culture gone, and nothing to replace it.

On the other side, mountains of calico cloth, a brisker movement of trade, a spirit of restless inventiveness, a growing population which could no longer be fed from English fields, and a few men richer and more dictatorial than it is good for any man to be.

The access of power, of productivity, which the machine brought, instead of operating to reduce toil and raise the standard of living of a roughly static population, had been drained away in a furious output of dubious goods shipped overseas, and the creation of a new misery-stricken population. The new hands were barely kept alive by the food imports which balanced the textile exports; the traders took a fat commission in luxuries; and the gain in power was turned into a social loss.

Reforms and improvements were only won with extraordinary difficulty. Indeed nothing substantial was won at all until about 1850—seventy-five years after the first Watt engine had begun to pound. The dementia of the times had hardened into a fantastic doctrine of free enterprise, which a modern psychologist could hardly fail to diagnose as a "defense mechanism." The "invisible hand," despite its thousands of visible contradictions, was flourished by such men as Pitt in Parliament; in town hall, in the press, wherever motion was made for social control. If child labour was in question, instantly the cry was raised that England's manufacturing supremacy was threatened; that capital was timid and would leave the country. In 1833 Cobbett pointed out that the opponents of the ten-hour bill for children had discovered the industrial greatness of England depended upon 30,000 little girls! And the same with proposals for living wages, sanitary improvements, factory inspection, housing.

We are beginning to know something about high wages, short hours, sanitary conditions, as aids to efficiency and sound economy. But no typical English master of the 'thirties ever had heard of such things, and would have deemed it utter nonsense, had he heard them. (Nor is his species extinct.) Granting the logic of the times, here was a serious dilemma. If conditions were improved, costs would go up, exports would fall off, food could not be imported, and the workers would starve to death. It was pointed out that it was better to be half-alive than altogether dead. The reformers were, in effect, murderers. To this impasse, at once ludicrous and tragic, had free competition and its machinery brought the cottage yeoman and craftsman of England.

Nor should we fail to remember, as the Hammonds have clearly shown, that the influence of the slave trade on British merchants was such as to brutalize their attitude toward all labour. They carried over their psychological conditioning in respect to African blackmen to the white workers of their own island. The word "master" ceased to mean a man who was master of his craft, and became one who was master of other men. In pursuance of this attitude, a very lucrative business sprang up in the farming out—or rather milling in—of pauper children. The waifs were collected from all over England. We find a contract between one thrifty Lancashire manufacturer and a London parish, in which the former undertook to accept one idiot child for every twenty sound children delivered. They were bound over in gangs for Yorkshire and Lancashire mills. "These little slaves worked day and night in relays, so that the beds in which they slept never cooled; one batch followed another in turn for its share of rest in the filthy rags."

Lest you think the philosophy peculiar to England, listen to an American historian:

> Perhaps most deeply influential of all New England migrations was that of the sturdy, rosy-cheeked farm virgins into the dark New England mills and their consumptive boarding barracks. By 1846 conditions were such that the Massachusetts mills were sending out 'slave wagons', whose commanders were paid for all the girls brought to market, at the rate of one dollar per head, and more in proportion if they bring them from such a distance that they cannot easily get home again.

Parliament conducted investigation after investigation. The same ghastly reports were handed in, and the same masterly inaction resulted. The legacy of it all is recorded, according to Pound, in the figures showing the fitness of Englishmen for military service in the drafts of 1914. The cockney regiments from the industrial centers—London, Lancashire, Cheshire, Glasgow—"were the dwarfed children of the mid-Victorian era. They could not march fast enough, carry pounds enough, fight hard enough. Some of them had big heads on small bodies, as if they suffered from water on the brain."

About 1850, however, a few major reforms took root. While they did not save the British worker from remaining half-alive, it is safe to say they saved him from degenerating further. They brought the biological curve to something like a level, and finally to a slight upward trend. Three champions came to strike aside the implacability of the "invisible hand":

First. Factory legislation, which shortened hours, raised the permissible age for working children, improved sanitary and safety conditions in the mills and mines.

Second. Civil Service, which made factory inspection and government administration something better than a farce.

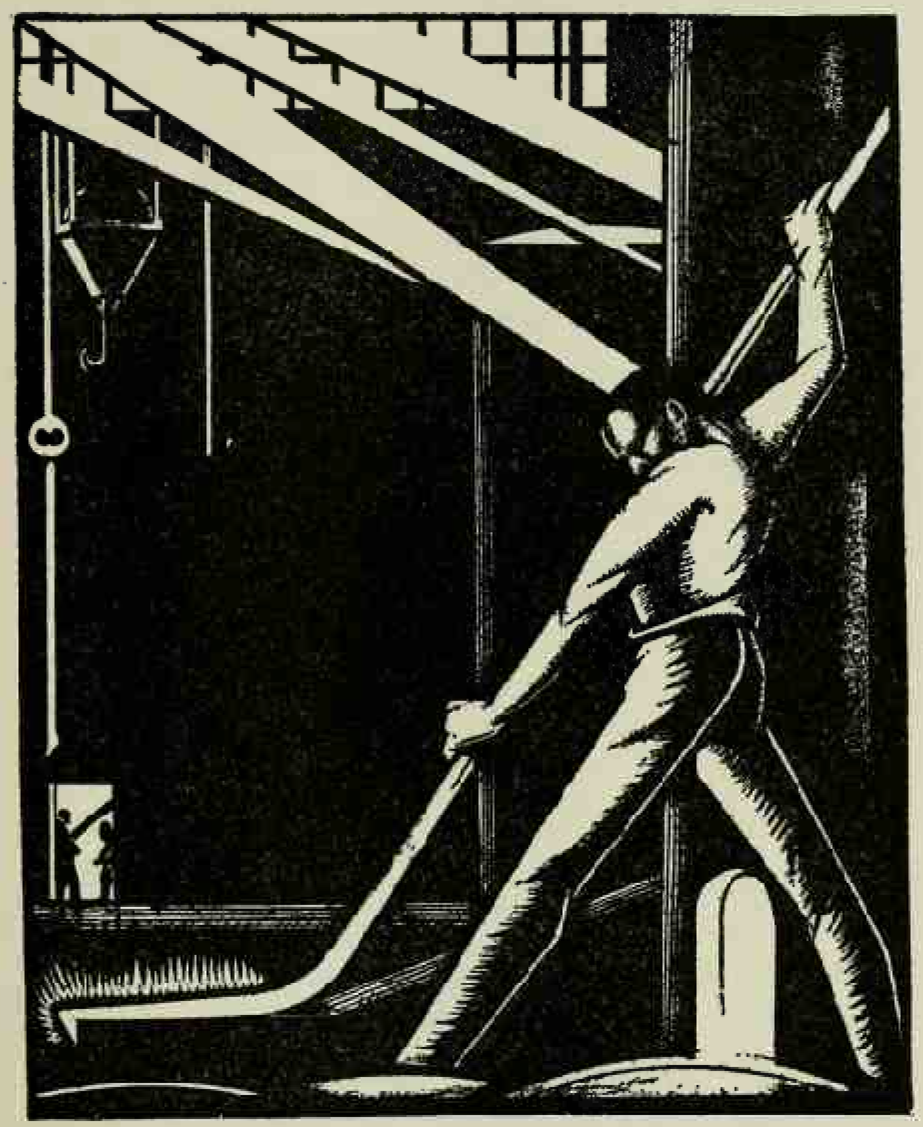
Third. Trade Unions, which taught the worker to organize for his own protection.

The terrible reign of the machine in the control of unmitigated *laissez-faire* was over. With the turn of the half century, sanity began to appear under the columns of smoke, and culture, with a mighty effort, to adapt itself to the steam engine. Nor, despite the despairing cries of the conservatives, did England's industrial supremacy vanish with the advent of these champions. What was gradually conceded in higher wages and factory improvements, was more than compensated by increased efficiency. As the decades passed, legislation marched deeper into the industrial field; the trade union movement grew stronger, attaching the co-operative movement to itself. Hours came down to negotiable proportions, wages almost held body and soul together, the children were kept out of mills and mines until they at least knew their A B C's and could dress themselves; there was a place to wash, the light and air were better, and the frightful harvest of accidents was materially reduced. While in the towns, parks, playgrounds and libraries were no longer luxuries, unsuited to the poor. But the profound loss of economic balance which the mountains of calico had wrought remains to this day. Half the population of England sprang from the loins of the machine. If the machine falters, providing no equivalent for the meat and bread which must come in, that half is doomed. Is it to be wondered that imperialism grows rankly in such a soil?

Finally it would be a serious mistake to suppose that all the reforms promulgated from 1850 to the present time, in England or in any other country, have done more than partially to deflect the social scourge which followed the coming of steam. Economic slavery, long hours, child labour, evil shop conditions, slums, industrial accidents and ugliness still obtain over wide areas. In the more recent factories of Japan, China, India, conditions as bad as those of early Lancashire have been reported. In November, 1925, a girl of thirteen was found at two in the morning with her head crushed under a spinning machine in a Shanghai cotton mill. She worked on the night shift, and had been scalped by a driving belt after she had fallen asleep. Other mill children have had their lips and teeth torn away. Two-thirds of the children treated in the Shanghai Industrial Hospital are the victims of machine accidents; mostly to the head and hand, and mostly on the night shift.

Who was to blame for this tragic failure in adaptability, particularly in the early years? With some show of reason one might blame the workers themselves. If they were such sturdy, independent folk when they came marching into Manchester as the historians proclaim, why did they not burn the factories, wreck the looms, and ride their owners on a rail, as conditions became intolerable? Here and there they did conduct a few desultory attempts to smash machinery, but by and large they meekly bent their backs and let the factory wheels run over them.

With more justice one might blame the masters. They not only promulgated the rules which made conditions what they were, but fought every inch of advance in Parliament. It would have been satisfaction to take out some of the engines of the Inquisition



from the museums for their benefit. . . . But they, too, were ignorant men; many of them genuinely believed that if only the mountain of print cloth rose high enough, conditions would somehow, sometime, right themselves. They saw their bales of goods, their new roads, canals, railroads and steamships, and felt that they were serving England—bringing her such gifts as the world had never seen before.

And here is an old Watt engine. He is soberly thumping away in a Lancashire outhouse; asking nothing of anybody save a little coal and a little oil and now and then a drink of water; trying his best to please, using his willing torque to get the tangle of heavy belts in motion in the morning—dazed and wondering before the avalanche of imprecations which humane men in his day, and every historian since, have hurled upon his head. Why was he to blame?

Steam culture

While the tragic human cost of the coming of steam was mitigated in many respects as the decades passed, the disequilibriums it set up remained, and still remain. In the chapters which are to follow, we shall examine them in some detail; here we have space to note but one or two of the outstanding mass effects—specifically, population, specialization, and the economy of cash.

The hordes of farmers that invaded the cities stayed in the cities. Since 1920 the United States has lost 800,000 farmers and gained an equal number of city folk. Russia, just beginning the process of mechanization, is increasing her city population by leaps and bounds. Steam culture demands great, roaring cities. Electric culture—which is on the way—may reverse the population flow, by delivering cheap power to rural districts. The tide, however, has not yet turned.

Steam culture helped to treble the population of the world. It grew from 700 millions in 1789 to two billions in 1925, due largely, in my opinion, to the machine. Observe the way the process works. England makes great quantities of cotton due to the new inventions. A new labour force is required to run the looms and spindles. Following the laws of economic vacuums, that force fills the new industrial towns. It breeds; it must be fed; nor can it be fed from English fields. In exchange for the cotton goods exported, food is imported. England is no longer self-supporting. Somewhere in the outside world, somebody must grow more food. The economic vacuum turns about and demands more farmers to feed English mill workers. In the Americas, Australia, South Africa, India, more farmers appear. They too breed.

More mill workers; more food producers—rocking from side to side, world population edges upward. In due time, sanitation and medical care cut down the death rate, giving population another lift. Rich new lands for colonization help; railroads and steamships help; many factors help. But the steam engine is at the bottom of it.

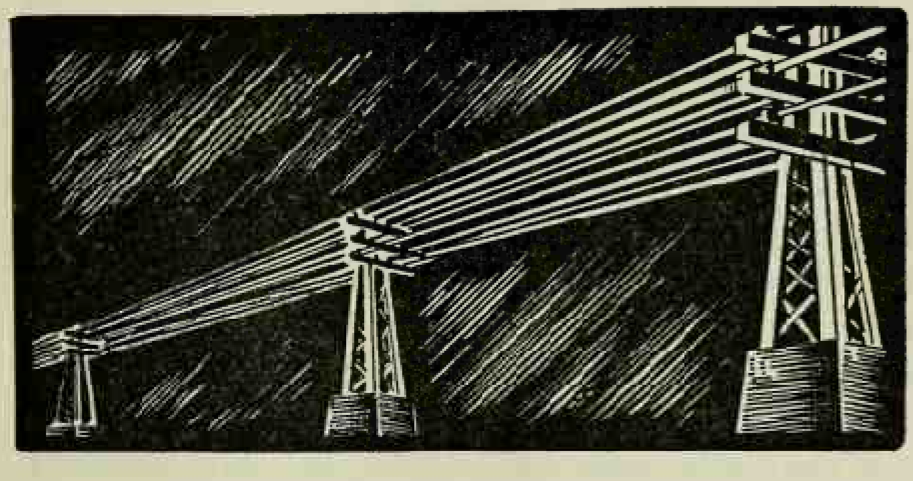
All this leads to what might be termed mass production on a cosmic scale—unit parts made here, there and everywhere, to be assembled into a world economy. Factories cluster along the Clyde, the Ruhr, the Merrimac; farms in the Dakotas, the Argentine; mines in the Andes, the Urals, Alaska; plantations in Cuba, Java, along the Amazon—each increasingly helpless without the others. Steam welds the world into an economic unit, displacing the thousands of self-sufficient communities which obtained before its coming. Rome with her grain fleets encountered the problem in a small way, but never before has it appeared on a planetary scale. I say planetary, because, while the manufacturing department is chiefly located in Western civilization, the supply departments, to say nothing of the branch stores, are to be found on every continent; on every populated island.

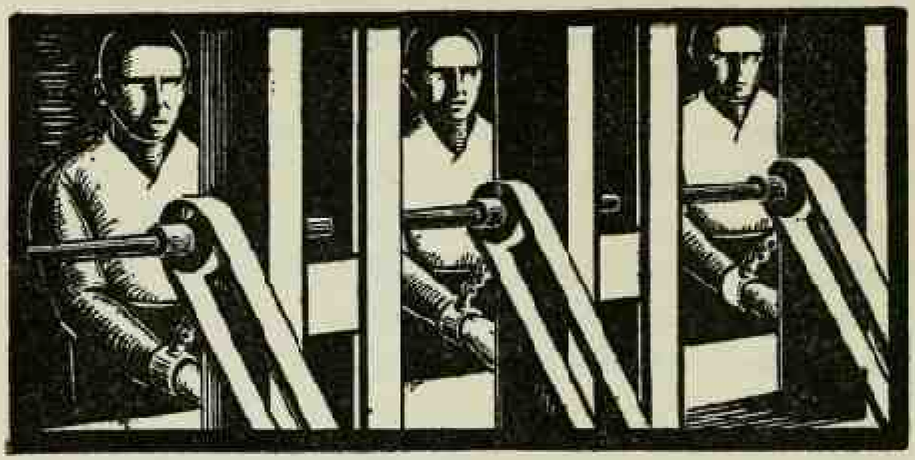
As the smoke rises, we find a surprising new phenomenon—the cardinal importance of cash. A jingling pocket has always been musical, but in its absence one could still stagger along. All previous cultures have based their economy on goods rather than on gold. Steam culture shifts the accent to gold, and for these reasons.

As trade increases its area, the feasibility of exchange by barter declines. A farmer with a loom in his house is not primarily dependent on cash. He needs a little of it every year, but he can feed and clothe his family without it. A mechanic in an automobile factory, a shop girl in a department store, can hardly get through the day without money. A cashless week may find them starving. No part of their daily labour provides them with consumable goods. They do not make anything which they can eat or wear. Edibles and wearables can only be secured with the money which must first be found. Inevitably this leads to the enthronement of money as the most important thing in life. As indeed it is in a specialized economy; as indeed it is not in the ultimate scale of human values. In the analysis of Middletown, referred to earlier, the investigators noted a steady growth in the pecuniary nexus from 1890 to 1925. They present this phenomenon as the most important change in social habit which has taken place in the last generation.

Many urban individuals, instead of knowing how to fend for themselves as did their ancestors, only need to know how to count their change, pull a lever, tighten a bolt, pound a typewriter, throw a switch, recognize a delicatessen store when they see one. They can survive in the Power Age with far fewer skills than can the most primitive savage in his jungle. This renders them more helpless than the men of perhaps any previous culture. The machine has reduced their economic security and independence. They can look no employer in the eye and consign him to oblivion; rather they must be forever licking the hand of some manager of personnel. The job means money, and money means life. The lack of it accounts for more suicides than arise from broken hearts.

But it still has to be proven that it is a more evil thing to be at the mercy of a weekly pay check, than at the mercy of the tides, the storms, the seasons, the Black Death, the lord of the manor, the pig sty and the gods.





CHAPTER VIII

ROBOTS

In one of the great establishments manufacturing automobiles, there is a room filled with punching machines. In front of each machine stands a worker, feeding it pieces of steel by hand. A lever is geared to the mechanism, and to this lever the man is chained by a handcuff locked to his wrist. As the punch comes down, the lever moves back, taking the hand with it. If for any reason a man wishes to leave the room, all the machinery must be stopped and his handcuffs unlocked by the foreman. To look down the long room is to see machines, levers and men in unison—feed, punch, jerk back; feed, punch, jerk back. . . . I have heard of no other single task today which so closely approximates the gloomy prophets' picture of the robot —that mechanism of flesh and blood first heard of in a Czechoslovak play, towards which, it is alleged, all men are moving. Yet these workers were handcuffed partly out of pity for their flesh and blood. Before the articulated levers were installed, they were, despite the guards, continually losing their fingers and their hands under the down thrust of the punch.[1]

The chassis assembly line of Mr. Ford goes (or did for model T) at the rate of six feet a minute. It contains forty-five stations, or operations. At station number one, mudguard brackets are fastened to the frame; at station ten, the motor is installed. The man who puts on a bolt does not put on its nut; the man who puts on the nut does not screw it home. At station thirty-four, the motor receives its gasoline. At forty-four, the radiator is filled with water; at forty-five, the finished car arrives in John Street.

Or take an outdoor task. "A mass of iron and steel, weighing up to 250 tons, is being driven seventy miles an hour, hauling a load of 6,000 tons up and down grade, around curves, through open country or congested cities. A huge hot fire is being maintained, creating a tremendous volume of steam power. The entire engine is in constant vibration, swaying and jolting with a peculiar unsteady motion. The sense of responsibility and latent danger always remains." The accident deathrate for locomotive firemen is nine times the normal rate, and their average age of death thirty-seven years. Tuberculosis also kills them because of the terrific changes in temperature to which they are exposed; heart disease kills them because of the loads of coal they have to lift, and the speed at which they have to work. Because of the ever increasing size of engines, and the ever increasing tonnage of the load, firemen have reached the breaking point of what is possible for human heart and muscles to endure. Therefore their union, despite the obvious threat of unemployment, is agitating for automatic stokers—machines to take the place of failing men.

---

[1] As reported by Mr. Ralph Borsodi.

By way of contrast here is a "steel bird." He is the man who rivets skyscrapers together. He is restless, adventurous, courageous and gay. He earns big money, is a mighty spender and a sporty dresser. He is often killed, but while he lives, he *lives,* and swaggers. The Power Age exalts his personality.

And here is Charles Lindbergh, minding a machine over 3,000 miles of ocean. So close was he bound to it, that he spoke of himself and it as "we." In a sense he loved it, and all the world loved him for that affection. I have not heard him called a robot. Nor yet such machine tenders as Chukhnovsky and Commander Byrd.

These cases of depressing effects contrasted with stimulating ones could be endlessly multiplied. They show the futility of blanket judgments for or against the machine, and its direct impact on human beings. We achieve nothing until we plow deeper, and break up the general process into specific classes. Even the locomotive fireman, for all his bitter labour, is not a bowed and beaten individual, while the engineer who sits beside him in the cab is one of the most sturdily independent men alive. Machine civilization is wide; it encompasses many thousands of kinds of work. It is astonishing to learn furthermore what a small proportion of the total population, or even of the total working population, is concerned directly with machinery during all the working day. Only a close and lengthy analysis of the 1930 census—when it comes—can disclose the actual percentages for the United States, but I can at least give a rough preliminary estimate, based upon the 1920 figures:

United States

Total population, 1920		105,711,000
Total gainfully employed		41,615,000
Factory workers, unskilled	4,278,000	
Factory workers, skilled	3,694,000	
Total factory workers (not including officials)		7,972,000
Other machine workers		
Stenographers and typists		615,000
Chauffeurs		285,000
Coal miners (estimated working machines)		200,000
Telephone employees		190,000
Delivery men		170,000
Brakemen		114,000
Locomotive engineers		110,000
Clerks (estimated working calculators, etc. continuously)		100,000
Locomotive firemen		91,000

Telegraph operators	79,000
Motormen	67,000
Laundry workers (estimated operating machines)	50,000
Elevator operators	41,000
Engine hostlers	25,000
Miscellaneous occupations	56,000
Total	10,165,000

The total amounts to about one-quarter of the working population, and ten per cent of the entire population; but it is fantastically exaggerated. Engineers have advised me that it is safe to say that at least half of all factory labour is employed at other work than surrendering itself to the domination of machines. It is either cleaning, carrying, sorting, carpentering, storing, shipping, digging, repairing, painting—a hundred chores rather than straight machine tending, or it is using machines at the will of the operator, rather than being used by them. Such work cuts 4,000,000 from our total.

There are similar reservations in many of the subsequent classes listed. All stenographers do not operate machines, or if they do, it may be for only short periods; all telephone employees are not at the switchboard; all delivery men are not driving trucks; and so forth. But suppose we allow these figures to stand. What we cannot allow is the classification as robots of workers who have interesting, manifestly ego-inflating jobs—particularly those who are in control of power engines. I propose to strike from the list accordingly all chauffeurs, delivery men, brakemen, locomotive engineers, motormen and engine hostlers. These people as a class have responsibility, independence and anything but soul-destroying work. The total comes to 771,000. I leave in elevator men—who frequently are not down-hearted, locomotive firemen, and miners —many of whom prefer the coal cutter to the pick.

Outside figure as above		10,165,000
Deduct: half factory force	4,000,000	
Trades as listed above	771,000	
	4,771,000	
Net possible robots		5,394,000

Five million out of 105 million is five per cent of the total population, and about thirteen per cent of those gainfully employed. Greece in her great days had five million freemen standing on the backs of twelve million slaves. I dare you to conclude that a population seventy per cent slave is a more wholesome combination than one possibly five per cent slave to the machine.

Again, factory population—our biggest item—has been steadily declining since 1920. Mass production and the automatic function are relentlessly substituting machines for machine tenders. Between 1923 and 1928, total factory employees declined by 1,250,000. Already we have noted power stations and factories without any workers at all. Mr. Televox moves steadily into their shoes.

The fact that the ratio of so-called robots is small, and growing smaller, is not encouraging to the case of the despairing philosopher, but it does not dispose of his case. Far from it. One does not need to be a sentimentalist to recoil from the thought of living in the volcanic stokehold of a liner, or of a lingering death from phosphorus or radium poisoning, and five million human beings in chains remains a ghastly total if it can be established.

It is alleged that this group suffers from injuries to the body, injuries to the mind, and collaterally, injuries to status as free citizens. The robot is crucified by industrial diseases and accidents; he is subject to a growing burden of mental maladjustment resulting in nervous breakdowns, neuroses and psychoses; he is becoming a sub-man, incapable of taking an intelligent interest in public affairs, and so a liability on the whole body politic. Let us consider these indictments in some detail, remembering at the same time their interlocking relationship.

The health of the industrial worker

There is little question that the initial stages of the industrial revolution in England and elsewhere were disastrous in their effects upon the workers. Robots were made and slain by the hundreds of thousands. There was relatively far more machine tending, as the automatic process was in its infancy, while shop and factory conditions were universally and intolerably bad.

The health of present-day workers is probably improving with that of the rest of the population. Take New Haven for instance—where nearly everybody who does not go to Yale, goes to work in the metal shops. In 1880 the death rate of the whole city was 1820 per 100,000; in 1925 it had fallen to 1250—a decrease of over thirty per cent. "During the past half-century a phenomenal thing has happened in the conditions of human life. Over one-third of the total burden of disease and early death has been lifted from its shoulders; and this is the result of modern science, applied directly to the problem of public health, and in part, of chemical and physical and mechanical and industrial science which have operated indirectly by raising the general standard of living throughout the civilized world." Thus Mr. C. E. A. Winslow generalizes from his own New Haven figures, combined with authoritative national totals.

The general level, then, has risen. What has happened in specific industries?

For countless centuries, Barnett tells us, stone was cut with the chisel and the hammer. In 1880 a machine—the stone planer—was invented to do the work. By 1895 it was in wide use. Stone cutters were reduced to half their former numbers. But for the men who remained, wages were increased, hours decreased, working conditions greatly improved—particularly in respect to dust, that greatest of all industrial killers. There was less seasonal unemployment, and, because the machines were expensive, better sheds than any hitherto known were erected over them, which they magnanimously shared with the men—who suddenly found themselves working a power-driven planer, in light, heat and comfort, instead of driving a chisel in a cold dreary barn.

The linotype came in 1887. By 1903, 7500 machines were in use in the United States and Canada, and the industry completely revolutionized. Hours of labour were cut from ten to eight; wages were increased some twenty per cent, regularity of employment was greatly increased—the old "tramp printer" disappeared, shop conditions were improved. The machine brought greater strain, but it was not one of speeded boredom, but of challenge to the worker's skill. "The amount produced on a linotype is directly proportional to the skill of the operator . . . he must think far more quickly than a hand compositor." This man may or may not have lost health—but he certainly did not lose intelligence; the machine lifted him further than ever from the robot class.

The famous old Massachusetts mortality table covering 230,000 persons in all walks of life, shows highest death rates for "females in trades," trainmen and teamsters, and indoor sedentary workers; with lowest rates for professional men and farmers. It is probable that this relative scale still obtains—except that there are now but few teamsters to drink themselves into an early grave. While the health of factory workers has been improving with that of the general population, as a class they undoubtedly die earlier than farmers and professional men. It is not necessarily machines which shorten their years, however, but indoor work. Garment sweating, with little domination by machinery, has been found to be one of the most unhealthy trades of all.

Mr. J. B. S. Haldane, analyzing death rates by occupations in England, finds that the two great destroyers are alcohol and dust. The most dangerous occupation is that of barman, whose death rate is two and one-half times the average for all. Tin miners and file makers, both breathing quantities of dust, follow with a rate two hundred per cent above normal. "Practically every man who works a machine drill in a tin mine dies of consumption." The lungs of coal miners are black, but their death rate from consumption is only half the average for all occupations. They are as healthy as lawyers in this respect. The next unhealthiest occupation is that of unskilled urban labour, with a rate of one hundred and forty-three per cent. Such labourers have little to do with machinery.

Dana, studying American conditions, agrees with Haldane in respect to dust. In country air after rain, one count has found 10,000 particles per cubic foot; in an abrasive factory the total jumps 160,000 particles. Flour, starch, soapstone, talc, wood dust, bran, clay, ore and stone dust are very prevalent in industry, particularly in such processes as surfacing, polishing, stone crushing and sand blasting. American tuberculosis figures collected by the Metropolitan Life Insurance Company in 1928 show death rates far above average for miners (except coal), pottery workers, stone cutters, grinders. Inorganic dust is worse than organic, and silica seems to be the most deadly of all. Fifty-seven per cent of all rock drillers, blasters and excavators examined in a recent New York survey, "were found to be suffering from a probably fatal pulmonary disease resulting from the inhalation of rock dust."

Industrial accidents

The English figures show seamen as heading the list of death from accident; four hundred per cent of the normal rate. This is not a robot trade, but a very ancient one. Then follow bargees, lightermen and coal miners, none of whom make great use of the machine. Recent hearings in New York indicate that longshoremen, loading and unloading vessels with little mechanical aid, suffer a far higher rate of accidents than factory workers. Meanwhile the introduction of the hoisting engine in the building trades has eliminated "much of the labour and most of the accidents involved when labourers crawled up uncertain ladders with loaded hods, or teetered up slippery planks with heavy wheelbarrows."

An exhaustive study of industrial accidents conducted by the American Engineering Council indicates that since 1920, while the accident rate per unit of output is declining, total accidents are increasing, both in number and in severity. Production is increasing faster than accidents, but more men are being hurt. The Council finds that machines have displaced the handwork which was intrinsically safer. "The number of machine accidents per worker is greater, and the severity of accidents greater, than under non-mechanized conditions." Secondly, automatic machinery has displaced operators working at standardized processes on non-automatic machines which could be thoroughly guarded. Man-power is now needed largely for repair work, and "such work is intrinsically dangerous and is scarcely capable of being standardized." In other words, the robot is disappearing, but in his place is coming a thinking individual who has a more dangerous job—even as the "steel bird" has a dangerous job. Thirdly, under mechanized conditions the speed of materials is increased, and exposure to accidents, other things being equal, greater. "The new safety movement will have to meet, not static conditions, but the increasingly difficult conditions of an industry that is continuously growing more intense."

The Council believes that the increase in the accident rate since 1920—and it applies only to a bare majority of industries, for a large minority show a declining rate—is a temporary phenomenon brought about by the second industrial revolution through which we are now passing. Adjustment is still imperfect to the new exigencies of mass production.

This implies that accidents can be controlled, and to a large extent they can. The United States Steel Corporation decreased its accidents eighty-six per cent in thirteen years. The Union Pacific Railroad has a shop record five times as favourable as the average for other large railroads. The Clark Thread Company has a record of 10,000,000 man-hours without an accident. In one of the plants of the du Pont Company, there has been only one minor—and no major—accident in eleven years.

If the management cares to pay the cost of safety work, accidents can be well-nigh eliminated. The great mass production industries are beginning to realize that they stand to save more than they lose by keeping men from unnecessary mangling—and so register how far they have progressed beyond the masters of Manchester. But the organized safety movement has a large task on its hands to convince the bulk of the smaller manufacturers that "maximum productivity is ordinarily secured only when the accident performance tends toward the irreducible minimum."

How shall we sum up this conflicting evidence in respect to the effect of the machine on the body of the worker? To me it seems—after reading twenty times as much data as I have quoted here—that while industrial diseases are manifold and productive of a great burden of human suffering, there is no evidence that they are getting worse, and considerable evidence that they are getting better. There is also much evidence that the hand trades, particularly mining, and those dealing in dust, are as injurious as many factory operations. While industrial accidents have shown a net increase in America since 1920, it is nothing in the nature of a landslide, and strong forces are at work to counteract the tendency. Fortunately for the worker, accidents have an unfavourable effect on corporate balance sheets. In brief, I can see no support for the claim that modern industry is progressively ruining the body of the labourer. Many are ruined. Even more are saved. The longer life-span figures cannot be argued away.

The machine and the worker's mind

We turn now to the central charge of the gloomy prophets—the injurious effects of the machine upon the worker's mind. Here the evidence is scantier and less conclusive. Psychology is still a science in embryo, and as Mr. W. F. Ogburn points out, we know little about what is happening to the central nervous system of the modern machine tender. A few facts are, however, available. One of the crying needs of the times is to find more. The amount of sheer undocumented nonsense in this category is colossal. I have read most of it.

To begin with, nobody seems to know whether mental diseases are on the increase for the total population, or for machine workers as a class. A health survey by the Boston Edison Company shows a higher rate of time lost through neurasthenia in 1925 than in 1915; a belt conveyor in a Middletown glass factory produced several cases of nervous breakdown among women packers—but these are the smallest of weather vanes. Against them may be placed the studies of Dr. Culpin of the London Hospital who finds that nervous diseases are a frequent cause of absence from work in industry, but "apparently this condition has little or no relation to the work or the working environment." Indeed he found a high rate of neurasthenia in a shop where working conditions were of the best, and a low rate in a shop where speeding-up and other conditions were far worse. But this is no more conclusive than the Boston and Middletown cases. The factor which worries and frustrates modern industrial workers more than all the machines ever heard of is, in my opinion, unemployment. Unemployment, as we shall see, is primarily a product of the Power Age, but as an inciter of mental disease it has nothing whatever to do with facing a moving mechanism all day long. The worrying is done at home and on the streets. It is an indirect, institutional effect.

Whether mental diseases are on the increase or no, medical men agree that such cases require as many hospital beds as all other cases combined. This looks, and is, serious, but it tells us little about *trend*. Modern health practice insists more and more upon the segregation of the insane and the mentally defective. In past ages they mumbled in the chimney corner, or begged on the streets. Society now takes care of them—which speaks well for society, but gives no evidence that there are more to be nursed. Of all men examined for the American army in 1917, one and a half per cent were found to be afflicted with mental diseases—while not less than twelve per cent were afflicted with bad feet; indicating that they were worse at the bottom than at the top. That great numbers of our fellow citizens are slightly mad is only too painfully apparent; but how many were in similar sad condition in the Middle Ages, when the only engines were perpetual motion toys that would not work? When monks and nuns, cut off from the most normal of all human relations, filled their own cloisters and overflowed upon the countryside? When the Holy Office was frightening the world out of its wits, and saints, devils, witches, magicians were as popular as the movies? When "all the forms of lunacy thrived, even producing types peculiar to itself, such as lycanthropy, in which men transformed themselves into were-wolves"? Every culture has its devastating psychological effects, and it is yet to be proved that machines are worse than black magic, or chattel slavery, or the blood sacrifice.

James Watt argued as early as 1785 that workers under the new régime "are to be considered in no other light than as mere mechanical powers . . . it is scarcely necessary that they should use their reason." The main resentment of the early craftsman against machinery was not that it displaced him, but that it bored him to death. Frederick W. Taylor, the father at once of high speed steel and Scientific Management, observed: "The ideal of efficiency in industry is to simplify the work to such a degree that it can be done by a trained gorilla." For many routine tasks it has been found that the feeble-minded make the best operatives.

Dr. Herman Frank is of the opinion that many industrial workers tend to be poorly developed mentally, and de-individualized. Judgment, initiative and native intelligence have been deliberately trained out. This has probably been a costly procedure for management, as it surely has been for men. Machines, particularly looms and conveyors, are responsible for much repetitive work, but a great deal of hand work (such as garment making) has been specialized as well, and is monotonous, even as rowing was monotonous work for galley slaves. Machinery is usually held responsible for killing the skill, judgment, initiative and responsibility in modern workers, but repetitive processes and specialization in non-machine trades do this also. And, it may be added, have always done it.

Henry Ford declares: "Of necessity, the work of an individual workman must be repetitive—not otherwise can he gain the effortless speed which makes low prices and earns high wages. Some of our tasks are exceedingly monotonous, but then, also, many minds are monotonous—many want to earn a living without thinking, and for these men a task which demands no brains is a boon. We are always looking for brains—and men with brains do not long stay in repetitive work. After many years of experience in our factories, we have failed to discover that repetitive work injures workmen. In fact, it seems to produce better physical and mental health than non-repetitive work." He argues that if such tasks were really disagreeable men would leave, but his turnover is very low, about two per cent a month. These conclusions hold for his plants all over the world.

Following the gorilla motif, Mr. Ford says that repetitive work in modern industry makes it possible for the first time in history to put the aged, the blind and the halt to doing useful work; of course within the limit of their strength and inclination. Certainly this is a condition not necessarily to be deplored.

A recent analysis of the kind of work performed in the automobile industry shows:

	Percent of Total Force
Machine tenders	40
Assemblers (on the belt)	15
Helpers for skilled workers	15
Labourers, clean-up men	15
Skilled workers	10
Inspectors	5
Total	100

The repetitive factor is strong in the first two groups—machine tenders and assemblers; together they account for sixty-five per cent of the total force. These are the men who can be taught in a day or two the few simple movements which the job requires. Further, it appears that these groups are gaining in numbers as against the other four. The automatic process is not as yet displacing the robot process in the automobile industry. (There is, however, as we have seen, at least one plant where motor car frames are made entirely by machines without the intervention of human hands.)

Mr. Fred Colvin, of the *American Machinist,* admits that he too has wept for the soul-destroying effects of the machine, and has urged the shifting of men from one routine job to another "to save their tottering reason." Indeed he has tried it in sundry shops—only to be overwhelmed with the resulting riot! The poor slaves did not want to change, and said so loudly and clearly. Here was a man lying upon a cradle on his back under the assembly line, screwing up a bolt. He had a comfortable position and an admirable rest for his head. When the management tried to shift his job, he threatened to quit. He was convinced he had the softest berth in the shop—"nothing to do but lie down all day, and getting good money for it." Repetitive work, if geared aright, makes for pleasant day dreams. "Most people do not want to 'express themselves,' and are much happier with somebody else taking the responsibility. The stolid look is a generic one. Such men are built stolid; they would be stolid on a farm."

A French investigator, M. Dubreuil, supports this view. He concludes that it is impossible to blame machinery for the "brutalization" of workers in the United States. Many have the gorilla appearance, but on tabulating their nationalities he finds them to be stolid peasants from Russia, Poland, Roumania. Many of the immigrants who are tending our machines were born with a dumb look. They have, in his opinion, been neither harmed nor helped. He ends with a penetrating suggestion. The real place to study the effects of the machine is not the United States with its fresh immigrant drafts, but France, where three or four generations of weavers and metal workers have been minding machines for a hundred years. Let him lose no time in beginning such an investigation; it should prove profoundly illuminating.

Dr. C. S. Myers reports three classes of labour, psychologically speaking. There is a recognized type which takes no interest in his daily work but is apt to satisfy his longings by recourse to pleasant imagination or day-dreaming. For him no repetitive task, however monotonous, is felt as such. So long as he is not asked to alter his methods or attend to new details, he remains happy. A second type resents his work, but strikes a psychic balance with sport or other outside activities. A third type is in continual revolt, and if kept at repetitive work too long, is likely to fly off the handle. He is invariably of higher intelligence than his mates in the other groups.

Federal and State Labour Departments, in coöperation with insurance companies, recently studied industrial accidents in New York. They announce this warning—lest we grow over-optimistic about the happiness of gorillas: "Monotony of routine jobs is responsible for many fatal slips. It would be well for employers to make sure that the men and women assigned to routine work are temperamentally able to stand the monotony." A recent study of the Psychological Institute of Paris concludes that adding machines and other calculating devices constitute a distinct danger to the nervous system if operated for more than two hours a day. A picked number of intelligent girls were given monotonous cross-stitching work. They learned quickly and their initial output was very large. After a while, however, it fell below the output of the girl of average intelligence. They had been slowly bored to inactivity.

R. L. Cruden, analyzing labour conditions in Detroit, concludes that "monotony may not be psychologically harmful; but it stifles initiative, and may operate as an industrial boomerang. Men with alert minds report that after eight hours of it, they cannot settle down to read or to think." They must find some emotionally violent form of escape in jazz, gin, the movies, tabloid murders, cross country motoring.

The philosophy of fatigue

A last exhibit should be given. It is not important because of what it has accomplished to date, but because of what it promises. Under the modern canons of production, particularly in big business, it is gradually becoming a matter of scientific demonstration that it pays, in cold cash terms, to safeguard the health of the worker. The safety movement, the newer aspects of motion study and scientific management, the reduction of hours to increase output, the announced "economy of high wages"—all bear witness to the tendency. It applies only less to the mind than to the body. We might term it "the philosophy of fatigue."

Excessive fatigue sets up poisons, reduces output and thus injures profits. Elaborate systems have accordingly been worked out for its measurement. The Industrial Fatigue Research Board of England attaches special counters to looms, and special meters on their motors to measure power consumption. It finds that in this class of work, Tuesday morning between 8:15 and 10:15 is the hour when fatigue is at a minimum. Every Tuesday morning; always at this time. Efficiency drops after 10:15 to lunch time; picks up afterwards for an hour, sags downhill the balance of the afternoon, reaching its lowest point at 5:30. On Monday, at 5:30, efficiency is 5.8 per cent below the Tuesday morning norm. On Friday, 7.5 per cent below. Friday at 5:30 is always the bottom of the curve. There is thus a daily and a weekly fatigue cycle. It is tied up with temperature and humidity as well as with physical work. As the day wears on, the temperature of the weaving sheds rises; as the week wears on the effect becomes cumulative—only the week-end stoppage bringing temperature back to normal.

With these facts in hand, the manufacturer, desiring to reduce costs and increase profits, takes steps so tc control temperature, humidity, speed of operations, motions of workers, hours, rest periods—that the fatigue curve approximates a horizontal line, thus keeping output at a maximum.

Carbon dioxide expelled by the lungs has also been used by Polakov to determine fatigue. As fatigue increases, more carbon dioxide is given off. Thus compositors on a night shift exhaled 2.5 cubic centimeters per second at 5 p. m., and 11.7 centimeters six hours later. Type foundry workers jumped from 3.1 to 13.3 in the same period.

Professor Kitson of Teachers' College, Columbia, has evolved an "interest measurement scale," ranging from 0 to 100, divided into ten steps. By its means he is measuring the amount of interest that a given worker takes in his job, and so throwing light on the moot question of square pegs in round holes. He has already given the test to some four hundred teachers, and is planning to give it next to groups of machinists and salesmen.

The National Institute of Industrial Psychology in England, with Mr. Balfour as its president, has been at work since 1921 on such matters as:

> Tests for the selection of the most suitable workers for different kinds of work.

Interest in work, and reduction of monotony.
Distribution of periods of work and rest.
Motion study—from the point of view of the worker's psychology.
Effects of illumination and ventilation on efficiency.
Rhythm in work.
Correlations between intelligence of children leaving public schools and the skill required in the various occupations they will normally enter.

The Institute has served over one hundred clients, involving many thousands of industrial workers.

No further illustrations are needed to drive home the point. Enough when I say that all over the industrial world today fatigue studies are being made, and highly ingenious methods to prevent it have been devised, and here and there installed—of which the commonest are shorter hours and rest periods. They are being made furthermore not for humanitarian reasons, but for business reasons. If and when the technique gathers sufficient momentum, it will become difficult for workers to degenerate physiologically; and as even the effects of monotony would register on the output curve, important psychological benefits might well accrue. In the latter case, the work must be rearranged or the worker transferred, if maximum output is to be attained. What other culture ever dreamed of such controls?

Enter the next ten factories that you pass, and ask the manager if he uses fatigue curves. He will think that you come directly from the nearest speakeasy. Not until you reach the nine hundred and ninety-ninth, will you see them actually upon the walls. But if they mean lower costs, bigger margins in the competitive struggle, they are bound to come—just as automatic machinery and mass production have come. They open limitless possibilities for keeping the bodily mechanism of the worker at par.

And his soul? I wonder how far it is necessary to lie awake worrying about a healthy man's soul.

From the mass of evidence, often conflicting, often incompletely documented, certain conclusions nevertheless emerge.

First. The initial effect of the Machine Age was to hurt the worker physically and mentally. It killed him, maimed him, infected, poisoned, and above all, bored him, as perhaps no other culture has ever done. This effect still obtains in altogether too many areas, particularly in countries which are just developing the factory system, and in backward regions of highly mechanized nations—say sections of the industrial South, in the United States.

Second. By and large during the past generation, the health of the industrial worker has been improving. He is living longer, suffering less from sickness, working shorter hours, sharing more in the comforts of civilized life. Since 1920, in the United States, the accident rate has risen, but the phenomenon is perhaps temporary.

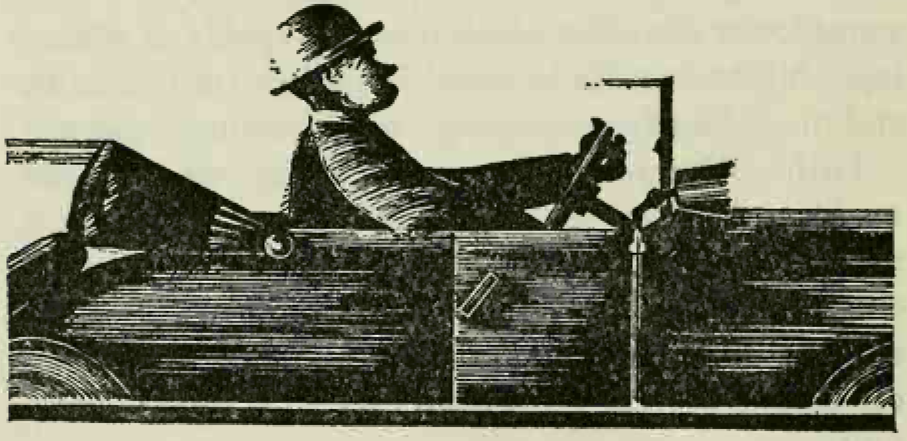
Third. The percentage of those engaged in monotonous repetitive machine work relative to the total population is small, and judging by factory employment figures in the United States, steadily growing smaller. At the present time not more than five per cent of all persons are so engaged.

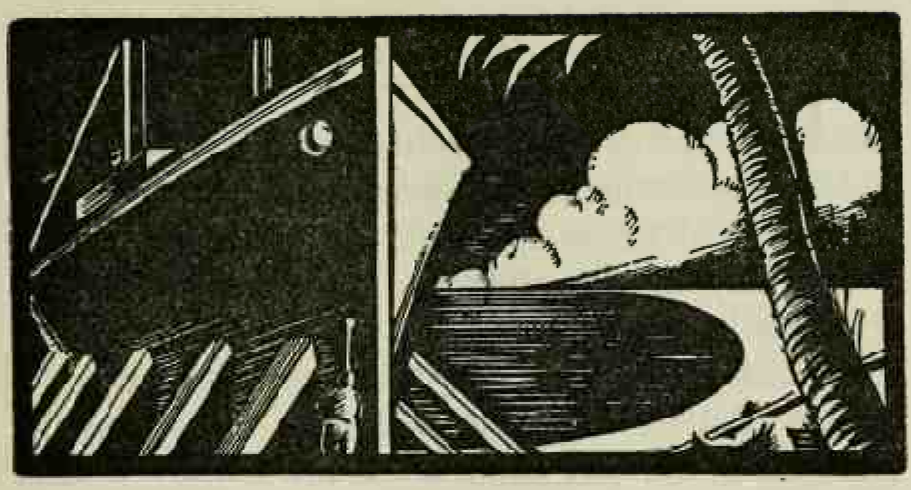
Fourth. Of the five million or so persons in this group an unknown total, possibly the majority, do not object to the character of their work, however strenuous may be their objection to rates of pay. Physiologically it does not appear to harm them, and psychologically they are glad to be relieved from all sense of responsibility. The question remains, however, whether industry is not guilty of deliberately conditioning them to a status lower than that which they are capable of achieving. Might they not be saved from their own stolidity, and made into free, thinking—and suffering—citizens?

Fifth. The remainder of the group who do not readily adjust to the repetitive régime constitute a major industrial tragedy. Unwilling robots, they are crucified in a ghastly and relentless process. No stone should be left unturned in setting up proper psychological tests to prevent them from ever entering the treadmill.

Sixth. Meanwhile two agencies are at work to lift the burden from both classes. Automatic machinery displaces the robot and replaces him with a skilled man. The "philosophy of fatigue" is beginning the long awaited task of adjusting the job to the physiological imperatives of the worker. Both have far to go.

Seventh. Finally we should remember that unskilled labour in pre-machine civilizations was frequently dull, hard, debasing work. Consider the pyramid builders, the burden carriers, the galley slaves, the hewers of wood and drawers of water. The machine comes to save us much of this grinding toil. Insofar as it is successful—and it has made an impressive beginning—it lifts the load of monotony from that group, and reduces the necessity for gorillas or robots in the whole social structure.





CHAPTER IX

SKILLS

In a lonely spot in the Pacific, on the night of August 10, 1783, the ship *Antelope* drove on the rocks off Pelen Islands. The crew of fifty men, including sixteen Chinamen, all managed to get ashore. Before the *Antelope* had broken to pieces on the reef, an improvised dock-yard had been set up on the beach, and the construction begun of a schooner in which to escape. Three months from the time of the wreck, on November 12, the new ship was launched; and she put to sea with all the some-time castaways safely on board. So well was she built that she was later sold at Macao for 700 Spanish dollars.

It is doubtful whether any crew that sails the seas today could duplicate this performance. One fears that the sorriest kind of a craft, if indeed any craft at all, would be the result of its labours in as many months as you please. If the marooned contingent lost its radio, the chances are that it would stay marooned indefinitely. Nor in the circumstances, if food was scarce, would I elect to be a Chinaman.

The day of the all-around man has passed for dwellers in the Power Age. Certain work we can accomplish with a very pretty skill—aided by our instruments, with an incredible skill—but thrown on the resources of our bare hands and a few tools, few of us could ever build a schooner, or survive any serious predicament at all. Consider, again, the one hundred persons who landed from the *Mayflower*. They immediately established a community; a microcosm of the culture they had left. Disembark one hundred assorted shopkeepers, typists, plumbers, lawyers, factory hands, realtors, garage men, shipping clerks, upon a wild but fertile shore and what would happen? The results are too painful to contemplate. For this reason, Mr. Austin Freeman contends with the utmost vigour that in losing our handiness, our unaided ability to face and conquer the conditions of our natural environment, the species is becoming atrophied, and thus less human. Biologically we are going backward.

Frankly, I do not see it. There is no evidence, to begin with, that we are going backward—or forward either for that matter. Biologically we appear to have remained static for 20,000 years; differing little from the Cro-Magnon man who drew pictures in the caves of France. We are primarily a tool-using animal, and if our tools are now bigger and more powerful, what of it? Instead of all-around skill, we have developed a great variety of special skills. This is admittedly to be deplored on desert islands, or in the event of a cosmic catastrophe—say the submergence of a continent—but who has set the date for the submergence? One does not wear a perpetual shroud because some day he must die. Why is it worse to live in a world of specialized skills if it means more peace, happiness, comfort, leisure, and no compensating psychic loss? Mr. Freeman will say that there has been psychic loss, but biology does little to befriend him; he cannot prove it. Specialization forces men to be less anarchic and more coöperative, a clear gain economically, and for all anybody knows, biologically as well.

Specialization can be carried to fantastic limits and become an active social disease. That it has been so carried, here and there in the modern world, is not to be denied, but this is no argument against specialization as such, but only against its misuse. In short, if I had to be wrecked on Pelen Island, I would choose the crew of the *Antelope,* but not confident of this disaster, I prefer to live in a suburb of New York, befriended by the experts who provide me with electric lights, a bathroom, and a furnace.

If skill *itself* has disappeared, the situation becomes far more serious. Were the old handiness to give way to nothing at all save a few simple repetitive motions, we should have plenty of cause for alarm. The muscles must be used, the hand and eye must have opportunity to coördinate or something will surely go to smash.

The vast majority of medieval artisans merely followed designs made by master workmen—even as we find it in the Orient today. The level of monotonous work under machine technology for great classes of occupations is held by Mr. Beard to be not worse but better than in the handicraft eras. Compare, he says, life in the latifundia of Rome or the cities of modern China with the life of a machine worker. "Those who are prepared to sacrifice the standard of living for millions to provide conditions presumably favourable to the creative arts, must assume a responsibility of the first magnitude."

Certainly many of the skills of England were ruptured when Watt's engines began to pound. Handloom weavers, chain and metal workers, tailors, cabinet makers, were driven first to reduce their prices, then to sweat the labour of all the members of their families, and finally to the wall. "The destruction of the labourer's only capital, his skill, is one of the most pernicious effects of machinery, and when it happens, there is and can be no remedy; still if the changes are gradual, the evil consequences are not so great"—wrote Professor Nicholson in 1892. Skill in this connection means the loss of an opportunity to sell an acquired manual art at a price which would have obtained if machinery had never been introduced. The industrial revolution ruthlessly destroyed skill as so defined;

nearly all the crafts were battered if not entirely undone.

But this only disposes of certain sorts of dexterity. Granted that they were ruined, did not others arise to take their places? They did. Consider the skilled intelligence needed to design, build, install, repair and inspect the new engines and mechanical devices. The skilled machinist, boilermaker, toolmaker, engineer, fireman, plumber, electrician, made their first appearances on any stage. Meanwhile great numbers of the class which, in the earlier dispensation, would have been common labourers, diggers of ditches, went to work tending machines. Their tasks were repetitive and simple, but many observers believe that they took a step upward in the ladder. They had to know more than on the old job. "One odd thing," says the editor of the *American Machinist,* "about the introduction of machinery is that while it is designed primarily to accomplish the transfer of the skill of the expert hand operator to a mechanism, and thus permit the employment of a less skilled and less expensive operator, experience has shown that its introduction is accompanied by a general improvement in the type of worker. More brains are needed to keep the machine functioning than to handle a shovel." Meanwhile Henry Ford is convinced that the number of skilled craftsmen in proportion to the working population has greatly increased under the conditions brought about by the machine.

Barnett finds that certain inventions, far from being introduced gradually, come relatively very quickly; eliminating hand work in a few years. The stone-planer was fully introduced in seven years; the linotype in ten, the bottle-making machine in six. But the use of the machine, even at its maximum development, is always narrower than the entire handicraft; some marginal hand workers remain.

The linotype brought a roaring new demand for printed matter and the linotype requires a skilled man to run it. The hand printer—if he was not too old—became a linotype operator, while many new men were broken in, leaving more skilled operators in the industry than before. The same thing happened with the bottle machine; a new demand, some of the old glass blowers falling by the wayside, the balance, plus a detachment of youngsters, going on the machines. With the Owens bottle machine, however—which came later—hand blowers numbering 9,000 were replaced by 4,000 skilled machine operators, in a period of twelve years. Skilled men declined in this branch of the industry.

Barnett's final conclusion is that while in some instances, such as the linotype, more skill is needed, by and large the effect of new machines is to reduce the skill of that particular process. Women and children operating power looms have none of the art of the hand weaver.

We must remember that many of the articles produced by machines are new sorts of articles, unheard of in any other culture. They crowd in on top of the ancient family necessities of food, shelter and clothing. Insofar as this happens, the factory does not affect the hand worker. He goes marching along, side by side with large-scale industry, doing his time-honoured tasks of tailoring, house-building, metal-working, what not. Rabinowitz, writing in the *International Labor Review,* finds that in Europe today persons engaged in handicrafts far outnumber those in large-scale industry. "Not only is the number of handicraft workers still considerable, but it does not seem to have decreased, either absolutely or even relatively to population." His careful study makes it appear that the Jeremiahs have been talking through their hats when they bid us, with tears streaming down their faces, regard the dying artisan. There are more artisans today than ever there were. This is certainly true of Europe, but more dubious for the United States—for which Rabinowitz has no figures.

Machines, strange to say, far from reducing the aggregate of handicraft work (again in Europe) have increased it. Their first effect was to reduce it, as the plight of the English artisans shows, but as the Power Age gained headway, inventing countless new processes and articles, additional tasks for the hand skills appeared. The factory machine does part of the work, leaving expert hand transformers, finishers, dressers, fitters to link the process together. Furthermore the factory has produced invaluable aids for hand workers in the form of sewing machines, knitting machines, motor driven hand tools, and so stimulated the crafts. "Large scale industry has provided certain old trades with the means of keeping alive and even of expanding. It has created and nurtured a large number of new handicrafts which flourish side by side with it, and which it has neither the will nor the power to absorb."

In short, regarding the whole field rather than one isolated trade, there is no conclusive evidence that the machine is seriously reducing the number of skilled hand workers. Rabinowitz looks for their survival for an incalculable period in the future.

Let us now turn to the new skills, never before seen on land or sea, which the industrial revolution has called forth.

> If, as conductor or engineman of an extra or an inferior class train running in the same direction, you held an order reading: No. 1 Engine 25 will run 20 minutes late A to C, and 10 minutes late C to Z, what time must you clear No. 1 at C? . . . In case the left back eccentric rod should break, what must you do?

These are two questions from the examination papers which all locomotive firemen must pass. A fireman has to learn all about forty-four types of locomotives, and at the completion of his training, must be ready to take the engineer's place at the throttle in any emergency. (Firemen have driven great trains long miles, with a dead engineer beside them in the cab.) Indeed so highly skilled does a fireman become that he is seldom fit for any other kind of job—except that of engineer.

There are some 200,000 railroad trackmen in the United States. They have to know how to build and repair switches; to lay and relay rails; tamp ties to hold elevation and surface; flag trains according to a complicated code; make adjustments to switch points; install frogs and guard rails; make emergency repairs to telegraph and telephone wires; build and repair fences; inspect track for spreads, sinking fills, swinging, heaving and buckling; learn and apply the formulas for shrinkages and expansions in rails due to changing temperatures. Each man has, at the same time, an immense responsibility for human life upon his shoulders. They are "sentries who guard a front 250,000 miles long. Day and night in baking heat or driving blizzard, trained men patrol the railroads' right of way." Finally, new machines are constantly being introduced into their curriculum—tamping devices, rail saws, welders—and with each, operating intelligence must be increased. In this occupation, skill varies directly with the amount of machinery.

The skill of toolmakers is far greater now than in the old handicraft days. This art, however, is very highly specialized. A generation ago, a good machinist would tackle any job in the shop, but now the man on the milling machine hesitates to undertake a task on any other. Mr. Colvin notes a growing lack of fundamental mechanical sense among modern toolmakers, due to specialization, together with increasing skill.

The art of the silversmith is a very ancient one. The machine cannot displace the craftsman in sterling silver work, but it can enormously assist him. Instead of chasing a bowl with his own muscles, he now uses a hammer driven by electricity—but as heretofore he guides its every stroke. In background work, the machine can improve the craftsman's performance; an automatic gauge can be set for strokes softer and more even than human eye and hand can emulate.

In the manufacture of airplanes, as we have seen, the craftsman is still the major factor. Skilled cabinet makers, instrument makers, painters, carpenters, planing mill operators, welders, tinsmiths, coppersmiths, seamstresses—work with the best of inspected materials upon a "ship" whose individuality they come to know and love. "This is the game for me. Do you think I could ever go back to house plumbing after watching a ship I worked on, hop off?" said a young plumber's assistant. Four hundred persons following twenty-one trades take 18,000 man hours to build a big three-motored plane. Their pay is high; their working conditions admirable; their adrenalin active by virtue of the "flying kick.". . . Somehow they put me in mind of the builders of Chartres. It is sad to think of mass production hanging, like a sword of Damocles, above their heads. The Fisher Body Corporation used to employ the finest class of skilled workers. When it was bought by General Motors in 1921, many skilled occupations were displaced by machines, conveyors and repetitive, specialized work. The sword had fallen.

While the building trades are the outstanding example of the craftsman defying the machine, the situation has begun to change, particularly in steel construction work. In the last generation the art of the mason, the carpenter, the bricklayer has suffered an ever-increasing dilution with common labour plus machinery. Steel frames, artificial stone, new metal ceilings, doors, casings, bases, shelvings, new paint compounds—all have driven building construction more and more into the factory, leaving less and less upon the job. The craftsman is turning into an assembly man—bolting together the standard parts which the factory makes. But the analogy cannot be pressed too far. Meanwhile a galaxy of new machines has appeared to aid construction work—pneumatic riveters, electric welders, stone chippers, hoisting engines, power picks, grab lines, conveyors, concrete mixers, gravity towers, cement guns, paint sprayers, floor scrapers, nailing machines. To operate these devices, new skills are required, of which that of the "steel bird" referred to earlier is one of the most dramatic.

The following table serves as a rough indication of certain of the old skills which the machine displaced in part and the new skills which the machine has created. On the assumption that Rabinowitz is correct, and that there has been no net decline in handicrafts, is there any doubt that the workers of the Power Age are, in the aggregate, more skilled, if more specialized, than the artisans of any previous culture?

The old hand skills:

Spinning
Weaving
Smithing
Wood-working
Ship-building
Stone-working
Pottery-making
Printing
Glass-blowing
The household arts

The new Power Age skills:

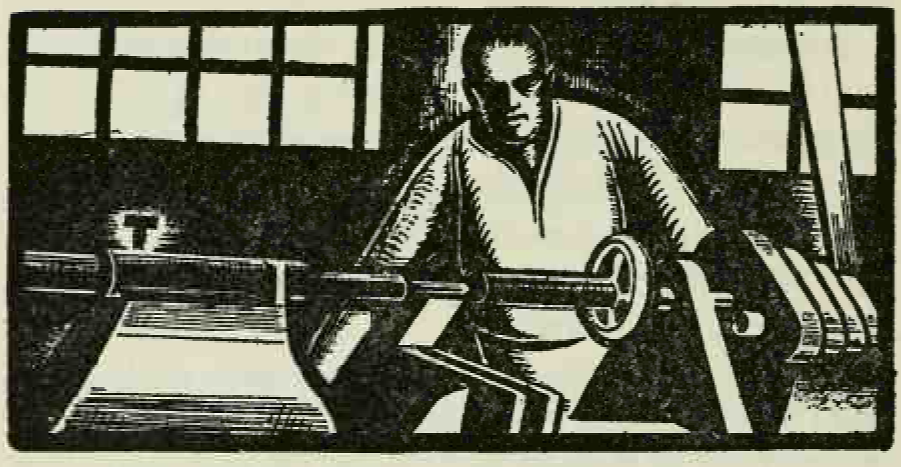
Engine driving
Track inspecting
Chauffeuring
Garage work
Steel construction work
Electric power servicing
Telephone and telegraph work
Camera and motion picture work
Production pre-planning
Sanitary engineering
Medical, dental and surgical work
Machine printing work
Radio engineering
Laboratory research
Prospecting and drilling
Caisson work
Airplane-making
Flying
Modern navigating
Modern tool-making
Accounting
Stenographic work
Barbering and hair-dressing
Publicity work

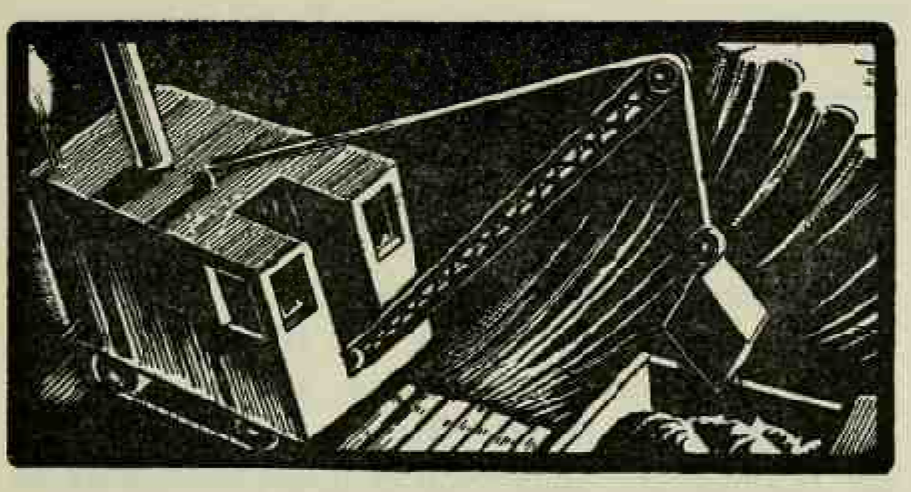
The list of modern skills could be indefinitely extended, utterly overwhelming in volume and variety the skills which have declined. The principle often touched upon earlier applies here and with equal force. When the machine controls the man, his skill evaporates; when he guides or controls the machine—as in many of these new occupations—his skill remains, and may even be enhanced.

There is one department where it seems to me that skill has been lost with no offsetting compensation. We have taken many of the housewife's tasks into the factory and left her to gossip, play bridge, buy more clothes than she needs, and make a sad spectacle of herself at so-called culture clubs. The poor woman has been left high and dry, after the children are big enough to dress and care for themselves—and there are not as many to dress as there used to be. The problem of the restless, neurotic middle-class woman is based on the fact that the machine has stripped her of her ancient skills, leaving nothing but boredom in their place. Nature has ever abhorred a vacuum.

For those gainfully employed there has obviously been no decline in skill. The robot class is relatively far smaller than that of the old-time slave or serf. The modern farmer must know more than his ancestors, and much of his new knowledge is enforced by the new machines—the tractors and the harvesters—he is called upon to operate.

The psychological effects of these new skills are a more dubious matter. As Simon Patten has pointed out in his theory of product and climax, the old artisan saw the product of his skill culminating immediately before his eyes. Satisfaction came as he worked. The modern designer may not see the tangible product of his labour for months; indeed may never see it. Satisfaction is delayed, or completely thwarted. Similarly much specialized work of the highest skill is only one tiny part of a great process, and often the worker has no picture of the whole process, or where his task fits into it. The machine has thus operated to split the psychological unity of work and result, and to take away a greater or lesser amount of the craftsman's completed satisfaction. On this score the gloomy prophets have a case, but it needs far more investigation before we can know how serious it is.





CHAPTER X

SAVING LABOUR

SOMBART, studying agricultural conditions in Western Europe in the Fourteenth Century, found hundreds of communities which averaged from 160 to 180 holidays a year. Mr. and Mrs. Lynd, studying Middletown in the United States in 1925, found a working-class population which, between hard physical labour and worrying about unemployment, were pressed reasonably close to the limit of what the human organism can stand. Their chapter entitled "Why Do They Work So Hard?" furnishes at once exhaustive and conclusive evidence of the tremendous pressure upon the modern industrial community.

The Fourteenth Century used the primitive tools of the Romans and Egyptians. Middletown was equipped with thousands of mechanical horsepower, and all the labour-saving devices of the Power Age. This seems a strange inversion: a great increase in machines, and a great decline in holidays; more power and less leisure. One can only ask again the question which puzzled John Stuart Mill half a century ago: How much labour do "labour-saving" devices really save?

They are constantly ousting men from their jobs as we shall see later in more detail, and thus saving a certain amount of labour. But it is debatable how far one can take any satisfaction in unemployment as an index of social gain, particularly when the hard work, to say nothing of the mental agony, of trying to find another job are counted in. Real labour-saving can hardly be reflected in the tragedies of unemployment; it must show itself in more rest, peace, security, an opportunity to breathe easier, a halt in the remorseless grind. Middletown never halts—save for a dash across country in the Ford on Sunday—and it is reasonable to conclude that its people, for all their machines, have not gained an inch in the quest for leisure since the Fourteenth Century. If indeed they have not positively lost ground.

There is no ready answer to Mill's question. The paradox is there for all to see, but the reasons for it are many and complicated. Among the more important is that Middletown wants—or better has been taught to want—more things than the Fourteenth Century. If wants expand as fast as invention, the standard of living conceivably rises, but all the labour that is saved in process A, must go to work on process B—national advertising or the implacable Joneses having created a demand for B. The community as a whole labours just as hard as ever.

Machinery in the last analysis can enable us to secure the same amount of commodities for half as much work (to take an arbitrary percentage), or twice as many commodities for the same amount of work. Neither goal, however, or any rational compromise between them, is possible without some sort of conscious social direction. The only direction known to Middletown is that of a few private individuals eager to secure a greater or lesser pile of stuff in the form of super-luxuries for themselves. Under such a criss-cross of purposes, the machine is as perplexed as the underlying population, and genuine labour-saving tends to go by the board. There are many other reasons, but this is certainly one cardinal answer to Mr. John Stuart Mill.

Let us examine the paradox in a little more detail. Here for instance is the automobile—a pretty child in its 1929 clothes. It is itself a labour-saving device—provided you use it as such. The machines which help to manufacture it, save incredible quantities of hand work. But what is the net effect on the total national labour burden—both in respect to consumers and producers?

Probably two-thirds of its use, disregarding trucks, is applied to doing something, pleasurable or not so pleasurable, which you as consumer would not have done had the motor car never been invented. You travel, visit, pay duty calls, "go out for a ride," move your home from town or city to the suburbs—ever deeper into the suburbs; you buy a summer place or camp—all because of the wider radius which the automobile has given you. Without it, you would still be in town moving in a smaller orbit. Granted that it is good for you to swing high, wide, and handsome, has it saved you any labour? Are you not planning, scheming and physically working harder with your rides, visits, tire changing, garage haunting, and the new obligations which the suburban house and the summer camp entail? Fords save farmers and mechanics labour—chiefly of the leg muscles; but how much saved labour does your Buick net you? This new animal requires food and exercise, and it is your destiny to give it to her.

Take now the other side of the picture. It has been estimated that it would require 1,000,000 men to build by hand 10,000 Fords, at a cost of $10,000 each. Lathes, milling machines, conveyors, have enormously reduced the hand labour which would be demanded without them. But to sell automobiles, alas, and keep them running on good roads, requires a fabulous amount of labour—new labour, new work, unheard of and unnecessary before the coming of the motor car. Here are the figures as compiled by the World Almanac in 1928.

AUTOMOBILE MAN POWER IN THE UNITED STATES

Direct		
Motor vehicle factory employees	375,000	
Parts and accessories factory employees	320,000	
Tire factory employees	100,000	
Total direct labour force		795,000
Indirect		
Professional truck drivers	900,000	
Professional chauffeurs	500,000	
Repair shop and garage employees	575,000	
Dealers and salesmen—vehicles	225,000	
Dealers and salesmen—parts	135,000	
Refinery and oil workers	110,000	
Highway officials and employees	100,000	
Tire dealers and salesmen	95,000	
Additional railroad workers	95,000	
Additional metal workers	85,000	
Financing and insurance force	30,000	
Machine tool builders	20,000	
Additional woodworkers	15,000	
Additional upholsterers	15,000	
Plate glass workers	15,000	
Road material factory workers	12,000	
Additional leather workers	10,000	
Total indirect labour force		2,937,000
Grand total		3,732,000

Here is work for 3,732,000 men and women, added in a few years' time to the American labour budget. The product which they make has provided them with jobs, but the gross exertion of the nation has, as a matter of cold fact, been stimulated by something in the nature of one billion man days of new work per year, while the net effect upon the consumers of the product has probably been to increase their work and care—certainly not to diminish it. If you built a great automobile plant in, say, Central Africa, and made the natives motor-mad, they might be happier, but they would suddenly find themselves with an enormous amount of new labour to perform—of which changing a tire with a hungry lion in attendance would be the smallest of items.

Take the modern cleaning complex. How can we call the bathtub a labour-saver when our forebears were sublimely unaware of the whole toilsome phenomenon of plumbing, hot-water heating, dressing and undressing two or three times a day, clean linen in piles, towels (they must be Cannon), bath salts, sprays, back rubbers, soaps nicely adjusted to every part of the anatomy? It takes a staggering amount of work to live up to the demands of our vendors of cleansing appurtenances; and it takes a staggering budget of labour to fabricate the same. To a citizen of the Fourteenth Century, the whole procedure would appear dangerously close to lunacy.

This reasoning holds with all manner of new devices and products which are not devoted specifically to the basic processes of food, shelter and clothing. The radio, the movies, the phonograph, chewing gum, cigarets, cosmetics, the bulk of printed matter—however efficient their production, have added to the national labour burden. I doubt if even the telephone has saved more effort than it has created. For every minute won, another minute has gone into running frantically around in wider circles.

Meanwhile a large proportion of labour devoted to the old line essentials of food, shelter and clothing has certainly been eliminated. It is the margin of that saving which makes it possible to have automobiles at all. As labour has been squeezed out of essentials, it has flowed into the superfluities—or the new necessities, as you please—with the same old time-clock on the wall. Here is the first great tax upon the work of the billion mechanical horses. Remember that no criticism of the process is necessarily involved. For all we know it may be an excellent thing to use engines for more stuff, rather than for more leisure. But regarding the actual stuff before us, one wonders sometimes if it is worth the price; if Middletown would not be happier with a five-hour day, and rather less in the way of cosmetics, Hollywood films, overstuffed davenports and electric refrigerators.

A second great tax arises from the fact that the specialization required by the machine makes for an enormous new establishment in which to function. In the old days one lived and worked in his own house—or in the fields nearby. One roof was all that he required. Now every factory and office employee requires two roofs—his house for the night and his mill or office building for the day. To double the square feet of roofage for millions of people requires a deal of labour. Indeed the whole capital cost of getting ready to operate the new machine civilization—a transformation still far from complete—has been a devourer of labour. When the new plant is ready, great savings should theoretically appear. But alas, it is never ready. New invention scraps one plant after another, and never has the turnover been faster than at the present moment. So in addition to provisioning ourselves, we have to build the whole industrial structure over every decade or so. The Fourteenth Century had only operating costs to meet, including normal depreciation.

A third heavy tax is to be found in the physical organization of the modern city. The machine and medical science have made the city possible, but from the standpoint of human labour it is distinctly a luxury. All that is needed to drive this fact home is to look down an excavation in one of its main streets—there will be one on the next block—and note the chaos of water pipes, gas pipes, sewer pipes, heating pipes, telephone cables, electric power cables, which are forever being laid, relaid, enlarged, extended, renovated and repaired. Cast up the man-power lost in traffic congestion; in delivering merchandise and supplies; in erecting buildings as "short-term investments," to be torn down in a few years' time as land values rise; in reaching out a hundred miles for a water supply; in carrying garbage twenty miles out to sea; in building subways which never solve the traffic problem but only make it worse. Labour is saved by metropolitan machines in detail, but the city which the machine has made possible is, as a total phenomenon, a colossal exhibit in excess human effort. The excess is roughly measured by the margin between the cost of living in the city and the country. To live on the same scale costs about twenty-five per cent more in New York than in outside districts.

A fourth tax is found in the phenomenon of ill-advised real estate booms. Take Florida, which I have recently visited. Throughout the state today one may view the ruins of a grandeur which never materialized. Here are hundreds of miles of paved subdivision roads in which the grass is sprouting; abandoned public utility systems; thousands of sagging monolithic entrance gates; enormous dredging, leveling, and sand pumping enterprises so remotely placed as never to be practicable. The best engineering talent in America was called to Florida in 1925, taking with it a vast labour force. They planned and dug and hoisted and leveled and built. The jungle is now reclaiming the bulk of what they did, and a rusting steam dredge, one crazy arm aloft, stands as the tombstone of their labour.

A fifth tax is taken by the factory itself. For certain products it is very dubious how much labour it actually saves. A competent economist, Mr. Ralph Borsodi, has demonstrated that he can grow and manufacture many things in his own home at a fraction of the price he has to pay the factory for them. Thus his wife makes a gallon of floor wax, including all labour and overhead charges, for $1.50. She cannot buy it for less than $3.50; and where her product is made to

Bureau of Standards specification and its quality always the best, the quality of the purchased article is far more temperamental. In her home I was served a meal where everything but the meat was provided at a cost below the retail market price, and of a quality calculated to drive the Canners' Association to despair. The demonstration, furthermore, was not founded on any formula calling us back to the good old days of cottage industry. In the home plant was every variety of modern serviceable machine—electric stoves, griddles, dish washers; steam cookers, automatic furnace, a tractor, cultivating machines; and their upkeep together with the home labour was carefully prorated in the cost accounting.

You object that people would rather buy a more uncertain quality in packages and cans. They would, and they do. But the fact remains that the total labour bill, compounded of farmers, factory workers and distributors, is greater than that of home manufacture—for certain articles. The application runs particularly to foodstuffs fresh and preserved, and to simple chemical compounds such as waxes, cleaning and toilet preparations, fertilizers, oils, disinfectants. The machine, by centralizing production in the factory, has, for these articles, when the costs of salesmanship and distribution are counted in, wasted labour rather than saved it. This sounds incredible and absurd. What we do not fully realize is the incredible and absurd degree to which the costs of distribution have expanded under our competitive economy. We see the factory continually eliminating its workers, but forget that these men, in effect, only run around and climb aboard the product on its way from the factory door to the ultimate consumer. Distribution costs go up as fast or faster than production costs go down. Much was hoped in this direction from the chain stores. Now it appears that there are so many chains in the field that fabulous rents are being paid for choice Main Street corners, with the result that the service accent is shifting from price to quality, and the earlier savings bid fair to cancel out in competitive warfare.

Again we must remember the terrific distances through which raw materials must be gathered, and the completed product shipped. If half a dozen great soap concerns are trying to supply the country from one central point—each with its national advertising campaign, and its complicated distribution system, we have a spider's web of effort which may quite extinguish the economies within the soap plant itself, and leave the little local plant supplying the neighbourhood, or even the householder supplying himself, a more efficient unit.

All this of course is not the fault of the machine, but of the going economic structure. One can readily visualize efficient factories, strategically located close to sources of raw materials, fed by cheap electric power, supplying their immediate localities with good products at a cost far below that which any single homeholder could duplicate. Such would, however, require a steady, calculable demand to which the production cycle could be adjusted, and the striking of every ballyhoo artist from the payroll—in brief, an economy based on the engineering principle of the "balanced load."

Machine versus hand

The last point raises the whole question of the superior efficiency of machine work over hand work. It is universally assumed that the machine is enormously superior. For many processes it is; as a total phenomenon it can probably be called superior—with the word "enormously" left out. There are, however, a number of considerations which need further analysis, together with a number of popular assumptions which are manifestly ill-founded. The machine, as currently controlled, is not always the champion that we have been led to suppose.

Let us begin with a few samples chosen at random showing the superiority of the machine over hand in any given process. (See pages 196-197.)

There is no end to such evidence. Its specific accuracy is open to some question due to the difficulties of making an exact comparison, but one cannot doubt the trend, or the fact that the margins between machine and hand for a given job are large and tending to grow larger.

But regard for a moment the item in which ten tractors displace five hundred men. Mr. Ford claims that in Armenia these tractors plowed one thousand acres of land in eleven days. To achieve the same result in an equal time would have required one thousand oxen and five hundred men, working according to local methods. Assuming a man to a tractor, and completely disregarding the oxen, we have here an efficiency of fifty to one in favour of the machine. Very good. Later on in his discussion, Mr. Ford says:

> Official tests with the tractor in England show that it costs, every factor taken into consideration, just half as much to plough with a tractor as to plough with horses.

The ratio of fifty to one has suddenly dropped to two to one! What has happened? Local conditions can only explain a small part of this amazing shrinkage. Has Mr. Ford made gross errors in his figures? No, I am confident that both sets of figures are substantially correct. The difference between them is contained in five words: *every factor taken into consideration.* Burn them into your memory, for no accurate comparison of machine versus hand labour can be made without them. Yet all the figures in the following table are made without them, while numberless business men, engineers and statisticians are announcing their achievements without them; filling the public mind and boggling the public eye with an impressive panorama of half-truths. A balance is struck before all the facts are in. It is obvious that in the tractor case only a fraction of the facts were in for Armenia. But in England, they were all in, and

MACHINE VERSUS HAND IN SPECIFIC OPERATIONS

Date	*Kind of Work*	*Hand*	*Machine*
1830	Spinning cotton	300 girls	1 girl
1860	Making corkscrews	59 men	1 man
1870	Lifting stone while repairing Cologne Cathedral	360 men	2 men & crane
1904	Producing a bushel of corn	270 minutes	41 minutes
1923	compared with 1780:		
	Iron output per man, day	500 lbs.	5,000 lbs.
	Lumber " " " "	100 ft.	750 ft.
	Nail " " " "	5 lbs.	500 lbs.
	Shoe " " " "	¼ pair	10 pairs
	Coal " " " "	½ ton	4 tons
	Paper " " " "	20 sq. ft.	200,000 sq. ft.
1924	Threshing wheat	135 men	1 man
	Plowing 1,000 acres	500 men + 1,000 oxen	10 tractors
	Men's boots	9 hrs.	1 hr.
	Cotton sheeting	106 hrs.	1 hr.
	Woolen shirts	76 hrs.	1 hr.
	Brussels carpets	8 hrs.	1 hr.

	Butcher knives	29 hrs.	1 hr.
	Marble slabs	539 hrs.	1 hr.
	Lead paint	17 hrs.	1 hr.
	Plows	32 hrs.	1 hr.
	Hempen twine	110 hrs.	1 hr.
	Iron pipe	18 hrs.	1 hr.
1925	Tamping ties	4 men	1 man
	Track lining	4 men	1 man
1926	Handling ashes	12 men	1 man
	Cutting wheat	2 acres (with horses)	18 acres (with tractor)
1927	Picking cotton	10 men	1 man
	Cutting stone	8 men	1 man
	Bottle making (Owens)	18 men	1 man
	Setting type	4 men	1 man
1928	Digging iron ore	500 men	1 steam shovel

the comparison came down to earth. Among the elements which make the difference, and which must be taken into consideration, are these:

> Labour required to build the factory in which the tractor is made.
> Labour required to supply materials for the factory.
> Labour required to construct the tractor—direct and indirect.
> Labour required to sell it.
> Labour required to repair and maintain it.
> Labour required to mine, manufacture, sell and transport the materials of which it is made, and the gasoline and oil which it consumes.
> Labour necessary to cover its rate of depreciation and obsolescence; i.e., replace it.
> Overhead labour represented by the interest and insurance which it carries.

Thus a veritable House-that-Jack-Built must be added to the simple comparison on the job, before any approximation of the true situation can be made. The men of vision forget Jack's House; leaving their calculations extravagantly erroneous.

The reason, besides sheer exuberance, for this airy disregard of nine points out of ten, is not far to seek. To include the whole house requires many dripping hours of calculation; if indeed it can be included at all. To follow all the twists and turns of the collateral labour which the machine demands, is a colossal task. (I have tried it once or twice.) There is one fairly simple short cut, however, which can be taken. The money cost, in the last analysis, is often a rough index of all the labour which has gone into a given commodity or service. If we can secure the machine-made delivered cost, and compare it with the hand cost, in a controlled experiment, we secure a reasonable approximation of relative efficiency. In the case of Mrs. Borsodi's floor wax and preserves, such a test shows no saving whatever by virtue of the factory process, but on the contrary a large loss. If it were possible to make similar tests for other commodities, we might find that in many items the factory-plus-delivery cost was higher than home manufacture costs (with home machines); and we should undoubtedly find cases where straight local handicraft entailed less labour than nationally distributed mass production articles—of which canned soup may be taken as an example.

Mr. Jesse R. Sprague cites the hypothetical case—which he claims to be typical—of a manufacturer of brass door-knockers. The manufacturer has established a local reputation for beauty and excellence and turns out twenty door-knockers a day which cost him one dollar each to manufacture, and sell for two dollars. A go-getting corporation buys him out and proceeds to install mass production, reducing the cost to fifty cents. But sales resistance is found to be stiff in the door-knocker field. In order to dispose of thousands a day, a nation-wide selling organization must be created, and a national advertising campaign duly launched, with sales managers, demonstrators, lecturers, counsels on public relations, and the celebration of National Door-Knocker Week. As a result of these heroic efforts —and heroic costs—it is found that the price must be raised to four dollars. But at four dollars the public will not buy in sufficient quantity, and the concern goes into receivership. "It is possible by Big Business tactics to force this quantity of door-knockers on the public, but such a pace could be maintained only by too extravagant an outlay. When the time was ripe, little business simply stepped back into the place from which it had been evicted." Machine production—"every factor being taken into consideration"—had proved two or three times as expensive.

A manufacturer, writing in the *Atlantic,* gives his actual experience. In 1926 it required forty minutes of total payroll labour to produce the unit article which his factory makes. (He is too cautious to tell us what it is.) In 1928 the time had been cut to twenty minutes. But his competitors had duplicated his efficiency, and as a result his selling costs had *doubled* in the same period, leaving him worse off than before. He inquires rather plaintively: "Are we the victims of our own producing efficiency?" His conclusions are not without interest. He believes that the present scale of output is excessive, that people are using too much unnecessary stuff. He believes that the point of accelerating unemployment has been reached, and that the self-sufficient worker with his home and garden is the man best able to survive the toppling over of the whole structure which is coming and which may force us back to primitive conditions. I cannot share his revolutionary prophecy, but I am ready to shed a tear with any business man loaded down with competitive overhead, and the costs of modern distribution.

One yard of cloth produced by a machine costs many hundred times as much as a yard produced by hand. Only if thousands of yards are produced does cost drop below the hand level. The greater the volume, the lower the cost, but if volume can be secured only by excessive salesmanship, the whole machine process defeats itself. Many articles now entering into the cost of living of the modern consumer are caught in this impasse.

In a motor car selling for $3,000, there is only about $180 worth of direct factory labour cost, while it takes $1,200 to sell the car—forty per cent of the total price. A certain motor accessory contains thirty-five cents worth of direct labour; the manufacturer sells it F.O.B. factory for $5; the consumer pays $25. "Selling is like locomotion. If you would double the speed, you must cube the power. The cost of forcing the last ten per cent of the output on the market, may easily eat up all the machine savings in production, and more besides."

In brief, modern industry is saving labour at one end only and that the less important one. It is whittling away manfully at production costs, which are often relatively small, and doing rather worse than nothing in respect to distribution costs, which are relatively huge. The labour earned in one department is thrown away in the other.

In our right hand is a model of Middletown, and by holding it to the light we can see tiny figures working, resting, playing. In our left hand is a model of a Fourteenth Century village on the Rhine, also with its moving figures. We look from one to the other and back again; following this man and that; following the activity of the whole group; trying to determine which is working the hardest, sleeping the soundest, eating the heartiest, drinking the deepest, and getting the most out of life. The Rhine village men work hard and long; but anon as the holidays swing round they are playing hard and long. The men of Middletown work shorter hours, but if they get a week's vacation in the year beside their Sundays and nine legal holidays, they are lucky.

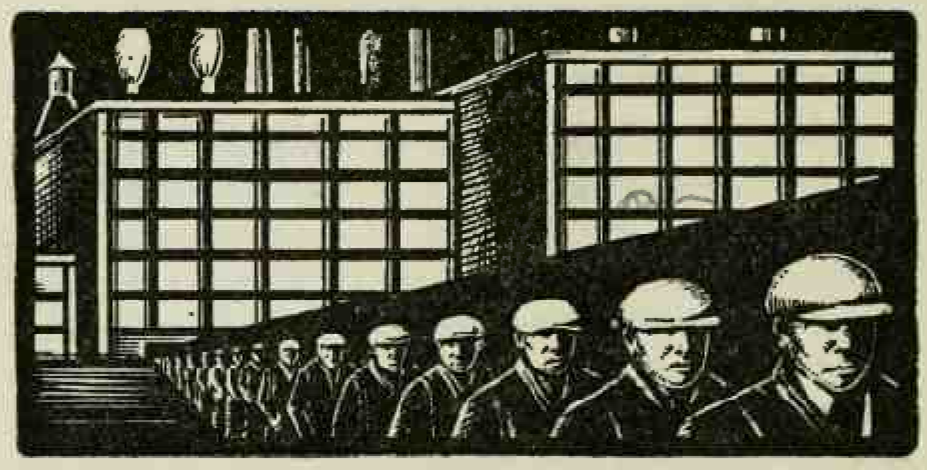
The movement of materials, the picking up and laying down of vast quantities of inorganic matter is incredibly great in our right hand as compared with our left. Freight trains full of such material arrive every day, and freight trains leave. The streets are dug to bury it and redug to lift it up again. The whole aspect of the town changes as the freight trains leave their staggering loads upon its platforms. Buildings come down and others go up; these come down and still others go up.

Above all we note that nearly everything the people of Middletown make is forthwith loaded upon a freight train, never to be seen again. Once in a great while, after long wanderings, a piece of it may come back for home consumption—say a storage battery—but this is an event. And everything that Middletown needs to keep alive comes in on freight trains. Only the local building trades make things that Middletown uses in any quantity.

But in the German village, here are the fields, the vineyards, the smithy, the slaughter house and the looms. Everything locally made is locally consumed. A peddler or two arrive, a wagon-load of fine wines departs, but no freight trains come lumbering in and out to puzzle us. The picture is direct, simple, and complete.

If we find, as I am afraid we do, that Middletown—for all its smoking chimneys—is working as hard, worrying more and enjoying itself less than the Rhine village, the reason seems to be in these piles of inorganic matter, these hectic streets, these subdivisions, these eternally burdened freight trains. More stuff, more congestion, more competing factories, more cross-hauling, than the Fourteenth Century ever dreamed of.

This all may mean Progress. It certainly means work.



CHAPTER XI

JOBS

We have seen ourselves in the mirror of Middletown surrounded by labour-saving machinery, working as hard or harder than ever. The multiplication of needs, the repair, the replacement, the overhead, have drained away the savings conceivable in a machine economy whose sole objectives were the abolition of poverty and the increase of leisure. Granting the rules of the game, however, the new work has operated to provide more jobs. If men had simply been displaced without a program for the simultaneous reduction of working hours, we should have been swamped with the unemployed. As it is, the problem of unemployment has been ugly enough, but ever since Watt, new tasks, useful or useless, have ultimately been created.[1]

---

[1] Please do not stumble into the pitfall of thinking that all this new work has been a boon, because otherwise half the population would have starved to death. If society had stuck to the old budget of wants, we should have been forced to cut the working day in two,

In the last year or two, however, a new element has made itself felt and is beginning to worry many thoughtful students. Has the machine in its last furious manifestation of mass production begun to eliminate workers faster than new tasks can be found for them, however long they wait? If this be true, we have encountered a mare's nest indeed. Those who work will continue to toil harder than in the Rhine village, but a mounting reservoir of unemployed will be created at the same time, composed of men who know neither work, nor leisure, nor indeed anything save tragedy.

Machinery did not inaugurate the phenomenon of unemployment but promoted it from a minor irritation to one of the chief plagues of mankind. As the road has lengthened from the origin of a commodity in the ground to its use by the ultimate consumer, the road from job to job has also lengthened. In village economy when the harvest season is over, one turns to lumbering or wood-carving—there is always work to be done. In the economy of the machine, the next job may be six months or a thousand miles away. Furthermore a new invention like the "talkies" may appear, and if one is a musician in a moving picture house, there may be no next job at all—unless one changes his profession. The new teletype-setter threatens to throw out of work ten thousand linotype operators.

keeping everybody employed, and supplying such a flow of simple food, shelter and clothing that starvation for any citizen would have been unthinkable.

The machine is irrelevant in any given process unless it can save labour. "One man and a machine replace ten hand workers"—is the essential saga of the Power Age. One man stays and nine men go. Society has gained a cheaper process, and nine men have lost their jobs. The final net gain is not always so clear.

In 1835 Charles Babbage wrote: "That machines do not, even at their first introduction, invariably throw human labour out of employment, must be admitted; and it has been maintained, by persons very competent to form an opinion, that they never produce that effect. The solution of this question depends on facts, which, unfortunately, have not yet been collected." Ninety-four years later, in 1929, unfortunately they have still not been collected. The United States has about the worst unemployment statistics of any civilized country. In the spring of 1928 the newspapers and magazines were filled for months with a vast debate as to whether there was, or was not, an unemployment crisis. Estimates of men out of work ranged from a few hundred thousand to six million—and nobody really knew anything conclusive about it.

As we have seen, the initial introduction of machinery into England caused no net unemployment, but the reverse. As prices fell, foreign trade rose, more machine-made goods were called for, and into the vacuum rushed farmers from the South, Scotchmen, Irishmen, even workers from the Continent. In the later stages of the transition, particularly when the power loom came into full production, the displacement of hand-labour assumed a more serious aspect. As England began to feel competition from other nations, the whole ghastly process of unemployment due to excess plant capacity made itself known—a process in which labour, lured to a manufacturing point in a period of sudden demand, is progressively laid off as competition, or shifting demand, whittles away the market.

With every new invention men and women lost their jobs. Sometimes they hit back. The rivermen of Cassel, sensing what was coming, destroyed Papin's fantastic attempt at a steamboat in 1707. The word "sabotage" is derived from the wooden shoes which French workmen threw into the gears of machines. But always demand, due to lower prices or other causes, came along and saved their necks. Not individually, heaven knows, but as a class. New opportunities, services, trades, opened for those whom machinery had displaced. The only proof needed of this general statement is that up to about 1920 unemployment was not a steadily progressive phenomenon. Bad as our own statistics were—and are—we are certain that decade by decade, from 1860 onward, unemployment did not grow larger in proportion to the total population. It went up and down; down and up; but the reserve army of the permanently unemployed did not tend to grow faster than population. The total firing rate did not exceed the total hiring rate over the whole period.

But since the so-called wave of prosperity, following the depression of 1921, has brought mass production and the automatic process to heights undreamed of, an uneasy suspicion has gathered that the saturation point has at last been reached; the "blotting paper" industries will soak up no more men. (The situation is aggravated, furthermore, by the increasing number of women who are invading industry.) Where are the poor wretches to go? The announced answer is the park bench; a bench which from now on is destined to grow longer and longer. A new job can no more be created as fast as the machine tips a man out of an old one. Accelerating unemployment is before us, and unless something is done, and that quickly, a very heavy bill, cast in terms of wretchedness and despair, will shortly be submitted.

After all, why not? Machine displacement is now proceeding at a faster rate than ever before; a perfectly fantastic rate as we shall see. Adjustments which used to have the freedom of the years must now be made in months. The costs of distribution have trebled since 1870, and it is reasonable to suppose that there is a limit to the men and women who can be packed into the line between factory door and ultimate consumer—retailers, jobbers, house-to-house canvassers and the rest. There is certainly one distributor at the present time for every producer, and in many trades the ratio is as high as two to one. Mechanical devices are already ousting skilled clerical workers and replacing them with operators who need not know how to add, subtract, divide or multiply. Orders are transmitted on conveyor belts with each checker or typist doing one operation. Office work is being measured by cyclometers, and square inches of typed matter. Twenty simultaneous check signatures are made with one pen. Opportunity in the white-collar services is being steadily undermined.

Again it is agreed by all competent economists that purchasing power has not kept step with invention. Purchasing power is the final arbiter of all jobs under the prevailing financial system. Unless prices fall as fast as labour-saving devices increase, the saved labourer must whistle for employment. With a static price level, he will have to keep on whistling. Prices have not been declining rapidly in recent years.

We have, then, at least three moderately reasonable theories for the zero hour of accelerating unemployment—unheard-of factory efficiency, a saturated distribution system, no assured expansion in purchasing power consistent with invention. . . . And if true, is it not all tragically ridiculous? Men are to tramp the streets by the thousands because machines can provide *more* than enough to go round. Perhaps the financial system under whose blessings we live is about to register a crowning example of its inability to adjust the Power Age to man.

The number of productive workers has declined in America, as follows, according to the United States Department of Commerce:

	1919	*1925*	*Decline*
Agriculture	11,300,000	10,700,000	600,000
Manufacturing and mechanical	10,670,000	9,770,000	900,000
Railroads	2,035,000	1,860,000	175,000
Mining	1,050,000	1,050,000	....
Total	25,055,000	23,380,000	1,675,000

The decline in 1929 registers over 2,000,000, and all recent counts of factory workers show a greater output with not only relatively, but absolutely, fewer men. For a hundred years every census tabulated an increasing number of persons employed in factories; now suddenly since the War, with an increasing population, there are fewer persons in factories. Something cardinal has happened; some mighty corner has been rounded.

Evans Clark in the New York *Times* shows the phenomenon by index numbers.

	Factory employees	*Production*
1914	100	100
1919	129	147
1924	116	158
1927	115	170

Production sailing upwards; employees dropping since 1919; with 1927 less than 1924. Between April, 1923 and April, 1928, more than 1,250,000 factory workers were permanently laid off, according to a recent survey of the United States Department of Labor.

There were 150,000 fewer railroad employees in 1928 than in 1923. Automatic electro-pneumatic systems of freight car control are eliminating switchmen.

Eleven men used to operate trains in the New York subways; now, with automatic controls, one motorman and one guard compose the crew. Nickel turnstiles have cut the number of platform men from fifteen hundred to four hundred and seventy. The Boston and Maine Railroad has a freight-handling mechanism to take care of a million freight cars a year. Switchmen and brakemen are eliminated; one skilled man in a tower directs the process. It saves the labour of at least four hundred workers. Ohio reports in 1927, eleven per cent more square feet of building with fifteen per cent fewer men. In the New York paper-box industry, the number of workers has declined thirty-two per cent since 1914, while output has increased one hundred and twenty-one per cent.

It has been determined that sixty per cent of a cigar store salesman's motions and speech are purely automatic, calling for no human initiative at all. Bright young men become shortly dull-eyed and bored. Why not give the work to a machine? Mechanical salesmen are appearing thick and fast. A department store is being organized which will have no sales persons at all —only the standard packages of national advertising to be delivered by machine.

Here is an electric hand-saw by which one man takes the place of four; a power-chisel which does the work of ten; a floor-sanding machine which puts five men on the street for every device installed. Two men now charge a steel furnace which once required fourteen men;

seven men cast as much pig iron as sixty used to do. In the liner *California,* three white-garbed firemen presiding over gauges, replace one hundred and twenty stokers. There will not be a switchboard girl for local calls in Washington by 1930; the dial system will have superseded every one. Cigar-making machines are ruining the cigar makers' union. The "talkies" have alarmed the musicians' union into raising a million dollar defense fund, but it is safe to predict that most of them will lose their jobs in the next few years. . . . Invention is eliminating labour at an unprecedented rate, and it is the man over forty who is being hit the hardest.

Recent figures, furthermore, show that the process is not confined to America. The Austrian Engineering Association has the intelligence to accumulate accurate data on the pace at which mechanization is proceeding. In 1927 just under 12,000 new labour-saving machines were introduced into the country, and they took away the work of between 40,000 and 50,000 men; 25,000 of whom lived in Vienna. Meanwhile output per man increased by some thirty per cent.

There is a further aspect of technological unemployment which should be mentioned. When Ford changed from model T to model A, he laid off 60,000 men for an indefinite period. The loss of their wages and purchasing power affected adversely 500,000 others in Detroit. Banks were hurt, instalment companies suspended, landlords were busy with evictions, the charity budget went up $600,000. Many of these men are now back after a year of idleness. But the case shows the inherently insecure nature of mass production in a competitive market, and the gigantic upset which occurs when the technological method is improved. Mr. Ford's whole charming philosophy of high wages, short hours, happy workers, the square deal, collapsed with 60,000 of his men upon the streets of Detroit. It is not good enough, Mr. Ford, not nearly good enough.

In the accompanying list I hazard a guess at where the productive workers, who have indisputably been displaced, have gone. I leave it to the reader to guess how much absorptive power these services still possess. A few substantiating figures are included from the Department of Commerce covering payroll increases between 1920 and 1928.

Apartment house and hotel employees—525,000
Beauty parlour experts, hairdressers, etc.—169,000
Teachers—185,000
Moving picture personnel—150,000
Radio personnel—125,000
Insurance agents—96,000
Doctors, dentists and lawyers—52,000
Telephone employees—78,000
Salesmen
Canvassers
Advertising men
Garage men
Filling station men
Roadside amusements
Taxi drivers and motor truck men

Service men for oil heaters, refrigerators, etc.
Blue sky stock operators
Wall Street croupiers and their overworked assistants
Florida and California realtors
Morticians
Highway construction workers
Soda jerkers
Bootleggers (casually estimated at 500,000)

The "blotting paper" trades tend to be non-productive. Some perform useful service, many are worse than useless, and serve to keep costs high, and choke the free flow of the machine. Furthermore, as nation after nation becomes industrialized, each with a surplus it is eager to export, no permanent relief is to be found in overseas dumping. That market tends to grow ever narrower.

Mr. Ethelbert Stewart, a most qualified observer, sees the higher level of unemployment in the spring of 1928 as perhaps "only the beginning of a more or less permanent unemployment, because a growing number of industries are equipped to produce more than consumers have money to buy, together with the supplanting of workers by machines." He cites the shoe factories of the United States capable of producing 730,000,000 pairs of shoes, of which only 330,000,000 can be annually absorbed—and calls it "typical of many industries." Mr. Horace Taylor is sure that "all evidences point to a steadily increasing technological unemployment," and many competent economists agree with him.

There is probably a limit to the absorptive power of even the bootlegging industry—particularly as it becomes standardized and mechanized.

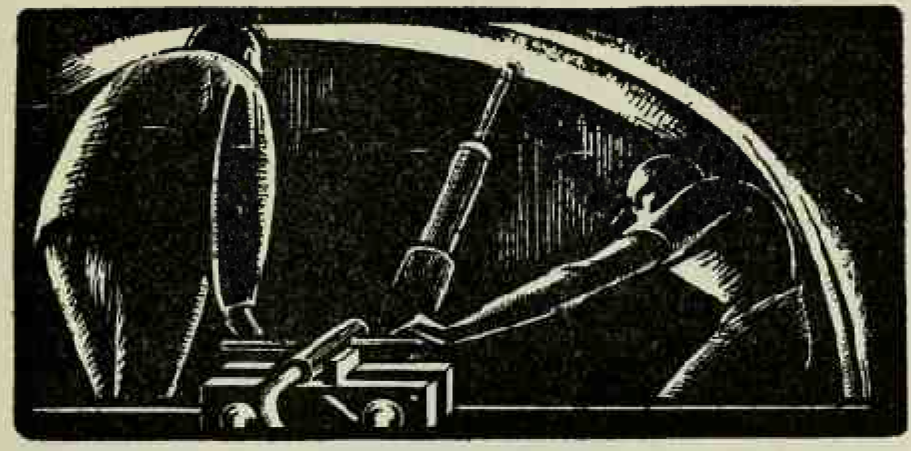
Seven hundred employees in three industrial communities who had lost their jobs were recently studied by Mr. Isidore Lubin of the Institute of Economics. Only forty per cent of those discharged during the twelve months prior to September 1, 1928, had found new work. Of these, one-third had to accept positions in industries entirely different from those where they had previously been employed, and nearly all had to take jobs having no relationship to the kind of work they used to do. Twenty-five per cent of those who secured employment had been out of work for six months or more. . . . This is probably a fair sample of what is now happening in every industrial community.

I am seriously afraid that accelerating unemployment is here; that the park bench is destined to grow longer. The advertisers may be able to stimulate new wants that will take care of some of the displaced men, but who is to stimulate the purchasing power that will absorb the commodities new and old? Only a profound readjustment in the whole operation of the financial structure—such a program for instance as that contemplated by Messrs. Foster and Catchings—can bring this vicious process to an end.

Let me recapitulate. Machinery saves labour in a given process; one man replaces ten. A certain number of these men are needed to build and service the new machine, but some of them are permanently displaced. Now if the articles called for remain the same, and the financial system remains the same, sooner or later, half the workers (let us say) in the country can produce what once required the labour of all the workers. The other half are on the park bench. But as an alternative, all can continue to work for half as many hours in the day. Or all can combine to work a full day and produce twice as much. None of these clean-cut alternatives has of course been taken. The ideal result would be something in the nature of hours reduced a third, and output of sound necessities and comforts increased two-thirds. This would end hard work and poverty forever. Instead, hours have fallen a little, output has increased considerably, but the present financial control neither releases sufficient purchasing power to enlarge output as far as the machine is readily capable of enlarging it unhindered, nor promotes the *kind* of output which necessarily makes for the good life.

If purchasing power has reached its limits of expansion because mechanization is progressing at an unheard of rate, only unemployment can result. In other words, from now on, the better able we are to produce, the worse we shall be off. Even if the accelerating factor has not arrived, the misery of normal unemployment continues unabated.

This is the economy of a madhouse. But it will take a genius to apply these obviously simple mathematical equations to the practical industrial control which will constitute a sane economy. The machine, God knows, is willing enough. To date we lack the directing intelligence to make it function.



CHAPTER XII

THE FLOOD OF GOODS

It was Diogenes who said that a man's wealth may be computed in terms of the number of things he can do without. On the basis of this definition, it would appear that the super-salesmen are making us poorer and poorer. That this is not altogether an epigram, a comparison of home expenditures for mechanical devices, indicates.[1]

In 1900

2 bicycles	$70
Wringer and washboard	5
Sewing machine	25
Brushes and brooms	5
Total	$105

---

[1] As prepared by Eunice F. Barnard.

In 1928

Automobile	$700
Radio	75
Phonograph	50
Washing machine	150
Electric refrigerator	250
Vacuum cleaner	50
Electric sewing machine	60
Oil heater	500
Sundry electrical equipment	25
Telephone, per year	35
Total	$1,895

The comparison is not strictly fair, in that allowance is not made for proper pro-ratings of the new devices over a term of years, nor yet for the value of the dollar, but it serves to make the point. We are paying for a staggering number of things which never entered into the budgets of our grandfathers, or even our fathers. Some of them are alleged to save labour, some even do save labour. Take, however, such an item as an electric washing machine. At home it is used a few hours a week. In a centralized laundry it is used throughout the week. By reason of its energetic promotion for home use, it is creating higher costs and less efficiency. This machine by setting up thousands of little individual plants run on a "peak load" basis, is wasting labour as compared with one large community laundry run on a "balanced load" basis.

A relatively small percentage of the Western world is in direct contact with the machine, in the sense of serving it all day long. A large proportion employs machines from time to time as the need arises. But everybody, without exception, uses commodities which the machine has produced. There is hardly a crack or corner in the planet where such goods have not penetrated. Even the most primitive of tribes have their steel knives and firearms; and where is the dinner table upon which the tin can has not climbed? I would guess that machinery has burned its brand into ninety-nine per cent of all manufactured articles entering trade today, and into the overwhelming bulk of foodstuffs. Peasants in India, China, Russia still grow and eat much of their own food without benefit of power engines, and barter in their villages a great volume of handmade commodities, but even this local economy declines before the assaults of factory textiles, hardware, and canned goods. In Russia, with distribution costs unencumbered by cross hauling, relays of jobbers and spirited salesmanship, it is hoped to supply many of the peasant's needs from the factory, at a lower cost than he can lay them down himself by village industry. Gandhi, on the other hand, is defying mass production by means of a renewed vigour in the handicrafts, but it remains to be seen if he is attempting to stem an irresistible tide. With a leaf from the Borsodis, he might make a good fight for it; but with Thirteenth Century methods, his case looks dark.

The extent of the flood

The gross output of manufactured goods in the United States has taken the following course since our own industrial revolution began in 1860. The figures are based on money values corrected for changes in the value of the dollar, and thus measure the relative progress of physical output.

	Value of manufactures	*Population*
1890	100	100
1900	131	121
1910	183	146
1920	260	168
1925	339	183

As the factory, during the whole period, has been engulfing products heretofore made at home, the sheer access of new material is not correctly reported by the table. The figures for manufactures are inflated as compared with population, by virtue of the preserves, soaps, textiles, hardware and what not, which were formerly fabricated in the kitchen and toolshed. Making all due allowance for this factor, the contrast is sufficiently striking. While population has grown eighty-three per cent since 1890, the quantity of manufactured products has shot up by two hundred and thirty-nine per cent, with the rate accelerating decade by decade, and particularly and dizzily since 1920.

We are, in fact, all cluttered up with progress. From the soil, rocks, forests, seas, subterranean caverns, comes pouring a flood of planetary crust, astronomical in its immensity. The mind reels before the total figures, and refuses to register anything intelligible. But perhaps they can be made graphic by reducing them to per-capita proportions. Suppose that a family of five persons, living in a suburban bungalow, elects to take its quota of the flood in raw materials, prior to fabrication and general loss and leakage. Piled up on the lawn—and it will have to be a bigger lawn than the realtor normally allows—will be the following material:

25	tons of coal
6	tons of quarried stone
1475	board feet of lumber
2.7	tons of iron ore
317	bricks
38	barrels of oil
7	barrels of cement
638	pounds of salt
180	pounds of sulphur
98	pounds of copper
67	pounds of lead
40	pounds of rubber

Scattered about there will be smaller heaps and piles of aluminum, silver, zinc, raw silk, cotton-seed cake, nitrates, antimony—to say nothing of tons of raw foodstuffs. It would take a steam shovel to dig our family out. Better than half the total tonnage is normally wasted in fabrication, transport and storage, but the end products which finally arrive, still make a tremendous showing.

These end products are not of course all deposited at the ultimate consumer's door. A great tonnage rests with the intermediate consumer as producers', or capital, goods, and consists of material for factory buildings, offices, stores, warehouses, railroads, steamships and the like, together with the machinery to equip the industrial, agricultural and transportation plant.

Goods delivered to the ultimate consumer may be divided for the purpose of our analysis into two general classes: first, the time-honoured staples of food, shelter and clothing; second, the new commodities and refinements—nursed by the interaction of expanding wants and aggressive salesmanship.

The time-honoured staples have probably increased faster than population since 1900, but their rate of expansion is as nothing compared with the new commodities. Between 1920 and 1928, according to Mr. Hoover, some 2,000,000 houses have been built, but the housing situation in the great urban centers can hardly be called spacious. The proverbial cat must shrink to a kitten before it can be swung with any comfort in the elegant one-room-and-bath-and-dining-alcove-and-folding-bed apartments, into which the urban dweller is increasingly crowding. Nor are the uniform square miles of suburban bungalows, each on its 30-foot lot, in much better case. For the families with incomes above $5,000, a decided improvement in both the comfort and appearance of country and suburban houses has taken place.

There has been no great gain in meat or bread consumption—judging by the plaintive wails from the respective trade associations. The soberer aspects of clothing are not quite all that cotton and wool manufacturers desire. Both industries are in the doldrums, constituting, with agriculture and coal, the four black marks on the shining mirror of American prosperity. Boot and shoe manufacturers are not complaining about an inability to fill their orders. In short, it is to be doubted if any appreciable part of the new flood is composed of the time-honoured staples. We are not as a nation housed more spaciously, fed more heartily, or clothed and shod more voluminously than a generation ago.

We are certainly housed more glitteringly, fed more variously and clothed more diaphanously, and where is the home without its garage, its antennæ on the ridge pole, and the twin wires—bearing power and talk? It is in these departments of consumer goods that the curve of output leaves the curve of population like an airplane rising from a flying field.

New commodities and services

Automobiles
Moving and talking pictures
Telephones
Radios
Phonographs
Player pianos
Electrical house equipment, washing machines, vacuum cleaners, etc.
Refrigerators, mechanical
Mechanical toys
Dandy little jiggers—cigar lighters, flashlights, safety razors, fountain pens, etc.
Airplanes
Bicycles
Cameras
Saxophones (and their friends)
Sewing machines

Refinements in old commodities

Chromatic plumbing
Automatic house furnaces
The Beauty Shoppe technique
Amusement parks
Cheap furs
Silks; rayon
Soft drinks
Candy, chewing gum and slot machine provisioning
Road-house entertainment
Tabloids, confession and personality magazines
Foodstuffs packaged, bottled and tinned
The cleaning complex — tooth pastes, antiseptics, deodorants
Medical service—the cost of which has enormously increased
Education—new school buildings, great increase of enrollment in high schools and colleges, correspondence schools with their 2,000,000 pupils
Funeral outlays — now getting back to Egyptian proportions with cremation urns at $1500
The first-cabin accommodations of high-speed liners
The paraphernalia of golf
Mechanical laundries
Coughless cigarettes

This is, I believe, a reasonably complete catalogue of the major items of American prosperity. It holds in a general way for Canada, Australia, and such other mechanized nations as have done with licking the wounds received in the late War. Quantitative statistics are not available for all items, but we can give some idea of the total volume in the United States, as follows:

Number of houses wired for electricity	18,600,000
Number of telephones	19,000,000
Number of automobiles (not including trucks)	23,000,000
Number of radio receiving sets	10,000,000
Motion picture palaces	20,500
Full length scenarios produced annually	800
Electric flat irons	14,400,000
Vacuum cleaners	6,700,000
Washing machines	4,900,000
Electric fans (house)	4,700,000
Toasters	4,500,000
Electric heaters	2,500,000
Electric stoves and cookers	1,400,000
Mechanical refrigerators	500,000
Newspapers per day	38,000,000
Monthly magazines per month	112,000,000
Cigarettes per year	97,000,000,000

Into such commodities have the piles of raw material which choked the suburban lawn been fabricated.

One's first reaction is a certain sympathy for the time-honoured staples, faltering in the race against these new and alien hordes. As a people we could have borne with a better balance between the two. Perhaps it would not have been too great a sacrifice to have exchanged a few million tons of assorted cosmetics, tabloids, correspondence school text books, automobiles, movie palaces, phonographs, radios, Coney Islands, tin cans, tooth pastes, and four separate lotions after every shave in a modern barber shop—for fewer slums, bigger bedrooms, more wholesome food, clothing at once more beautiful and more durable, and above all a great shipment of staples down to the two-thirds or so of all American families which still balance precariously on the margin of the budget of health and decency.

A second reaction, and one which is pertinent to our inquiry, is the amazing perambulation of the machine itself—out of its appointed place in the power house and factory and into the list of consumer goods. Save for such things as watches, pianos, and a few hand-tools, mechanical devices for a hundred years were almost exclusively an item of capital. The bicycle started the stampede over the line, followed by the telephone and the phonograph, and now it would appear from the above tables that probably the bulk of the outlay for new consumer goods goes for machines, primarily the automobile. Over half the articles listed in the catalogues of the great mail order houses are machines and their accessories and parts.

Which brings us to a brief philosophical interlude. How far is the whole phenomenon of prosperity, progress and mass production, since 1920 in America, but the shadow of the automobile? Without it, should we have had the phenomenon at all? It was the motor car which brought installment selling to perfection, and so created some six billions of temporary purchasing power out of nothing at all. Then the technique welcomed radios, phonographs, player pianos, electric refrigerators and the rest, into the fold. If we should cease to buy automobiles at the present rate, what would happen to "prosperity"; would it go down like a house of cards? I am inclined to agree with Mr. Virgil Jordan that prosperity is an over-worked word, and that it "has been achieved in part at the expense of the older industries furnishing the basic materials and the fundamental services."

The quality of the flood

The flood of machine-made goods contains an unknown but considerable element of useless material. The remaining, and by far the larger fraction, is presumably useful material both for the ultimate and the intermediate consumer. But what shall we say of food stuffs poisoned with mineral salts, houses of green lumber that sag and crack, shoes that fall to pieces within the month? The margin of adulteration is enormous, as we shall see. But is this the fault of the machine? Are machine-made goods inevitably of a lower quality than hand-made? What is the level of quality that the machine actually gives us; and is it giving us its best?

Compare a Hoe printing press—that diabolic modern marvel—with the primitive hand press of Caxton. Merciful Heaven, what a gain! Then compare its flimsy, fading output, with the sturdy folios which have come down the centuries. Merciful Heaven, what a loss! Here is a Fourdrinier machine with perfect coördination, turning out five miles of paper in one spasm, at a speed greater than a man can walk. What is the function of this triumph of engineering? "To produce the worst paper that has ever been made, or that it is possible to make." An old Cremonese fiddle maker would scarcely deign to look at a log of sycamore which had been seasoned for less than half a century. Today, a German violin manufacturer stamps his instruments by the thousand out of steamed green wood; blows them together, and bakes them brown in an oven to give the antique finish. A craftsman cannot afford to waste good work on bad material, but all materials look alike to the machine.

The factory owner is not a craftsman. He does not personally make anything; he does not know how. He is primarily a dealer in materials and labour, and his function is not to make, but to sell. The commodities which issue from his mill are but counters in a purely financial transaction. "He is indifferent to their quality so long as they fulfill their commercial function, and the limit of their badness is the limit of the consumer's tolerance—which is not easily reached, since the purchaser can buy only that which is offered for sale." With the decline of handicraft in certain fields, a standard by which the factory article may be judged no longer exists.

Mr. Austin Freeman owns a copy of *Roderick Random* printed upon a hand-press in 1824, at which time it sold for five shillings. It is still sound and undiscoloured. He argues that if power machines produced books as good as this, their rapid output would soon become functionless because of increasing accumulations. Factory textiles come and go, but good English meltons go on forever. Factory furniture sinks into decay, while Eighteenth Century chairs and tables are still sturdy. The hand-made boot will outlive a whole dynasty of its McKay competitors. The business man often cannot tolerate durability, because of the brake it puts upon sales. Big investments demand big turnovers. Imagine a modern department store deliberately seeking to sell a vacuum cleaner good for a generation, as sewing machines once were! A leading merchant of Middletown speaking before the Advertising Club said: "Our policy is to appeal first to style, second to price, and last to quality."

In *Printers' Ink,* a magazine devoted to furthering the profession of advertising, Mr. Brian Rowe with commendable courage develops the same theme. He discusses the creation of obsolescence as a sales device. He wonders "why we struggle to keep waste out of manufacture, and deliberately encourage waste in consumption." He notes a growing tendency to speed up changes in style to shorten the life of commodities once made to last; and he cites specifically:

Men's clothing
Hats
Collars
Kitchen utensils
Motor cars
Phonographs
Watches
Spark plugs
Crank case oil
Furniture

Quality, he holds, is getting worse, and obsolescence is "wilfully created by an increasing number of manufacturers."

Quality in textiles is dependent on the normal period of style changes. In women's wear, this may be only a matter of a few months. The goods will fade and go to pieces if worn longer. The dye manufacturers are attempting to popularize the idea of better—and more expensive—dyes, but the textile men are loath to rise to the bait. Indeed why should they? Having conditioned the public to leap briskly from one *dernier cri* to the next, what is the use of making material which will outlast the leap?

Indeed the textile men are by way of being hoist with their own petard. Having taught the public to accept, if not demand, rapid style changes, they create a situation of the utmost insecurity and chaos in their own industry. Gambling is rife; competition is terrific; new capital is continually breaking in to make a quick profit on a new style. Mills fail and bring less than the junk value of their equipment; while a well organized band of scalpers waits on the outskirts ready to buy them at five cents on the dollar. The scalper then dumps the goods upon the market at far below legitimate cost because he has no capital charges to reckon with—and thus ruins the business of other manufacturers. Recently a group of textile men purchased a bankrupt mill, and dispatched workmen with sledge hammers to smash the costly and delicate machines, and so prevent the customary undercutting! The prices at which new machinery may be purchased in this warfare are fantastic. The highest bid for the $500,000 equipment in a new worsted mill that had failed, was $10,000. Looms costing up to $2,000 were knocked down for from $7 to $112 in a recent case. What chance has either the consumer's need for quality, or the machine's ability to supply it, in this mêlée?

In the following list are set down instances of inferior quality in machine-made goods which have lately come to my attention. The reader is invited to add his own experience; nor do I doubt that he can extend it indefinitely.

Foodstuffs

- Decaying ketchup
- Ginger ale largely composed of pepper
- Adulterated sweet chocolate
- Canned food containing hairpins and cigar stubs
- Dangerous preservatives in milk
- Glue, zinc and copper in gelatine
- Worms in canned cherries
- Peas and rice hulls in coffee
- "Pure Olive Oil" composed mostly of cottonseed oil

Housing

- Paint that peels and cracks off in a few months
- Leaky plumbing
- Dubious hardware—kettles, nails, hammers, locks, window fasteners, screens, screws, safety pins, hooks
- Temperamental oil stoves

Inaccurate thermometers and scales
Rotten mattresses
Insecticides—as a favourite food for insects
Bed springs that soon weary of their loads
Brooms that abandon their straws
Heatless blankets, 96% cotton
Rickety furniture
Moulting davenports
Short-lived sheets and towels
Fading curtains and couch covers
Bad looking-glasses
Warping hard-wood floors
Windows that shut, refuse to open, or open, refuse to shut
Violet ray glass that deteriorates in 2 months' time
Electric heaters which burn out in a week
Keys that break inside the lock, and locks that will not release the key
Veneering sold as "solid mahogany"

Clothing

Shoes—bad in material and worse for the feet
Worthless socks, underwear, shirts, neckties, collars, pajamas, gloves
Suits whose elbows give out in a season
Leaky and splitting raincoats
Dissolving straw hats
Fading bathing suits
Exploding bathing caps
Silk stockings that fade and run

Recreation and Education

Books which go to pieces
Magazines whose paper turns yellow

The contents of the ordinary "gift shoppe"
Disintegrating motor cars
Rotten radio sets (about 90% of all)
Screeching phonographs
Clockwork toys which survive just one winding
Bad tennis rackets, balls, baseball gloves, hockey sticks
Tin pan pianos
Rotten fiddle strings

Personal

Cheap jewelry
Unreliable wrist watches
Leaky fountain pens
The bulk of cigar lighters
Trunks and hand bags with the bursting complex
Tottering typewriters with self-knotting ribbons
Clotting, fading inks
Edgeless razor blades

We ultimate consumers have to take what we can get, and in altogether too many cases it is far from being good enough. The intermediate consumer, frequently purchasing his coal, cement, steelwork, machinery, bricks, plumbing—to standards and specifications, secures on the whole far better quality. The great variety of goods now thrust before the attention of the householder with all the tricks of high pressure selling, has brought about a peculiar paradox. The more he reads, the more illiterate he becomes. The candy manufacturers warn him with imposing medical authority against tobacco, and the cigarette manufacturers, with equally imposing authority, against the noxious sweets. He stands goggle-eyed before a thousand advertising campaigns pulling him in as many directions. The sense of quality, durability, value, which was strong in his less lettered grandfather, has well-nigh evaporated from his more lettered self. The authors of Middletown find this "new illiteracy" to be one of the most significant symptoms of the Power Age.

Certain observers believe that quality is definitely on the decline, that the flood of goods is turning to a contaminated, muddy stream before our eyes. Others are not so sure. As I comb the documents—cursing my fountain pen the while—I am not so sure.

To begin with, the definition of quality was bound to shift with the coming of the machine. If the quality covers the period of use, what more can one ask; particularly if a less expensive product is the result? In operating high-speed steel, it has been found that maximum efficiency and minimum cost are obtained by using a cutting tool which wears out in a short time. To make a more durable tool is uneconomic. How absurd it would be to put a motor engine good for twenty years upon a frame that had a life of five. The Deacon's wonderful one hoss shay was the soundest sort of engineering—all the parts wore out together. I see no reason why quality should not be lowered or raised to fit the specific need—provided the waste of raw materials is not too severe, and provided the buyer knows exactly what he is getting. This the machine is better equipped to do than the craftsman. The latter's art forces him to make the best possible article. The machine is insensible to such considerations, and will make you a shirt as rotten or as lasting as you care to set the control devices.

The Owens glass bottle machine, besides enormously increasing output per man, greatly improved the quality of bottles. No hand blower could touch the nicety of the machine product. No silversmith has nerves steady enough to do the fine chasing work which machines can lay down upon sterling silver. Gas ranges and heaters as a group have risen markedly in quality and safety since the Gas Association set up standards a few years ago. Fire fighting material has been improved by the Underwriters' Laboratories. Whatever may be your grievance in respect to telephone service, the mechanical equipment of the telephone and telegraph industries is of a remarkably high quality.

It is debatable, I think, whether quality is declining as a total phenomenon. It is certainly being lowered in certain industries, and being raised in others. The new commodities, insofar as they are by definition useless, have never made any pretensions as to quality—their aim was to appeal to the essential monkey in us all.

Many machine-made products are better than the craftsman's best; while for other products the machine average is distinctly above the craftsman's average. The craftsman's eye and hand is a gross and bungling instrument where workmanship demands measurements to the thousandth of an inch. The finest hand workers ever born could never make a first class automobile engine, or electric lamp. They could, on the other hand, make a better motor car body. We have noted how the quality of Fisher bodies changed when the machine took over the process in toto. But the mechanical bodies were good enough for their purpose, and were very much less costly—a consideration of the first importance. It all depends on the article. If quality can be comprehended in the technological process, the machine can do the better job. It never tires; its strokes are always uniform, and they can be infinitely soft or infinitely heavy—according as the gauge is set. But if quality lies outside the technological process, machinery can only produce a cheap and nasty imitation, worthless to use and horrible to gaze upon—of which the German factory-made fiddles may be taken as an example.

What we need is a comprehensive survey to determine those articles that can be made better and cheaper—all factors considered—by machine than by hand. It should cover not only end products, but all intermediate stages. If it appears that the hand-made boot is the more durable and better fitting article in the long run (a dubious enough assumption), is factory-tanned leather still good enough for the bootmaker to use? If it is not, can it be made so? Where should the machine stop, and the hand work commence, in order to assure us products of adequate durability and beauty? The technological process has never been given an adequate chance to prove its worth.

Pending such an inquiry, I undertake the dangerous task of giving a judgment—preliminary, I admit—of a few articles and processes to which the machine rightfully belongs; together with processes from which it should be forcibly ejected.

Where Power Machinery Belongs

In making other machines
In all metal refining, and smelting
In coke and gas manufacturing
In weaving all but the very finest textiles
In rubber manufacturing
In glass and bottle making
In quantity printing and paper making
In cigarette rolling

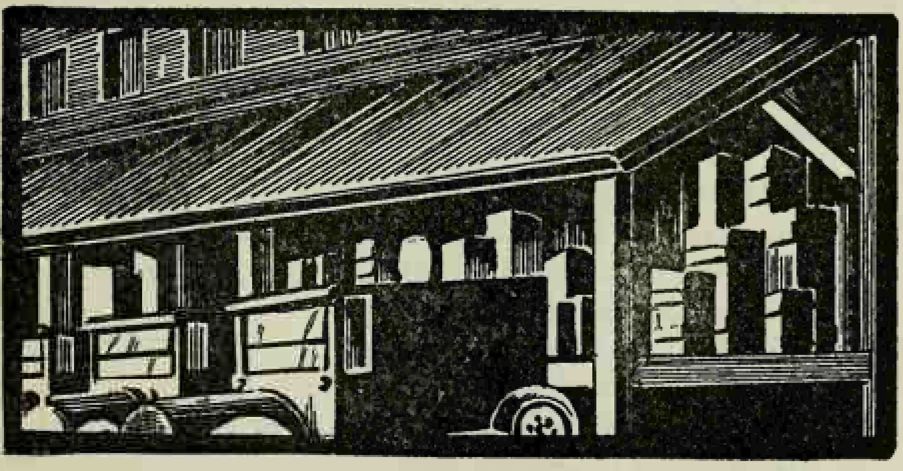
Where It Does Not [1]

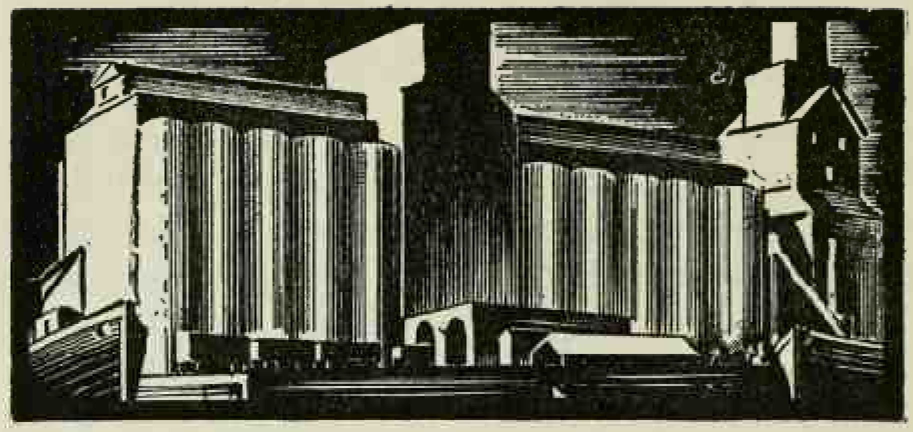
In food preserving and canning, where succulence is a desideratum
In fine bread making
In much leather working
In all finer grades of furniture
In high-grade musical instruments
In certain reproductions of sculpture
In ornamental ceramics
In ornamental metal work
In fine bookbinding and printing
In much jewelry work

The flood of goods in recent years has deluged us with articles of an exquisite nicety; and with unlimited tons of cheap and nasty stuff. But again, why is the last the fault of the machine? A man can lift no more than his muscular structure allows, and a machine can produce no better goods than its technological structure permits. If we burden the man with a greater weight than he can carry, should we whip him because he lies in the dust? Under a machine process more wisely controlled, one sees no reason why many if not most articles could not be produced durably; beautifully—where beauty was demanded; and at a cost far below that of hand manufacture. With less clamouring salesmanship, slower fashion changes, why should we not have better clothes, boots, housing, recreation facilities, food stuff, printed matter—fabricated in whole or in part by machines whose technological limits had been respected, not outraged and betrayed by bungling profiteers?

---

[1] Power-driven hand machines guided by the craftsman always belong. This is axiomatic.





CHAPTER XIII

SKYSCRAPERS

THE gloomy prophets bewail the state of the arts under the grinding processes of the machine. Mr. Lewis Mumford invites them, with as much impartiality as they can muster, to inspect the following exhibits of architecture inspired by the Power Age:

Brooklyn Bridge
The Marshall Field Warehouse in Chicago
The Monadnock Building in Chicago
The Los Angeles Public Library
The Hotel Shelton in New York
The Barclay-Vesey Building in New York
The interior of the Hill Auditorium at Ann Arbor
The Railroad Station at Helsingfors
The Town Hall at Stockholm
The Bourse at Amsterdam
The Concert-hall at Breslau

All these structures bear witness to a new architectural synthesis. "There has been nothing since the

Seventeenth Century to equal them in vitality and originality of design." In the face of these lovely, towered masses, comparative analysis may be in order, but hardly black despair.

Up to the time of Watt, work, play and art tended to be three interwoven parts of an organic whole. The plow, the craftsman's bench, the housewife's skills, the dance, the festival, the cathedral, all combined to produce the national personality. This organic unity survives among all nature peoples—such as the Samoans—today. The only historical exceptions are in countries which delegated manual work to slaves. In Greece and Rome, the cleavage between work ("the vulgar arts") and art became pronounced.

The machine, taking the place of the slave, has had a similar effect. The robot has been cut off from any creative function in this work; the artist produces more for millionaires than for the masses. When all is said and done this is the major aesthetic count against the effect of the machine. It has too often broken down the organic whole into over-specialized activities.

Art for the classes is a less vital thing than folk art, but it by no means precludes the creation of mighty and enduring works—as the age of Pericles bears witness. But Watt ushered in no age of Pericles. For a century every aesthetic form, save music and perhaps painting, was buried in a cloud of smoke. Up to the time of Ruskin, it was possible soberly to conclude that machinery had degraded the arts, when it had not utterly destroyed them. Architecture was replete with bulging excrescences, mansard roofs, brown stone fronts, and ghastly wall eyed compositions in red brick and ornamental iron work. Furniture and decoration had been ruined by the jig-saw and the planing machine. Pottery took to figurines of shepherdesses suitable to grace the parlour whatnot (an admirable name) ; while clothing ran to crinoline, the bustle, cylindrical black pants, the hour-glass waist, and the pointed shoe. The barrels of cannon, the girders of bridges, the frames of the earliest typewriters, were embellished with cast iron flowers, birds and fruits. From 1830 to 1890 "there is not a book, a piece of furniture, a pattern in textiles, a cup or saucer of new design which deserves a place, except as an historical curiosity, in a museum of art."

Prior to 1750, man did not tend to make his environment hideous. He either left it alone like the Amerindian, or added the charm of medieval castle and village. . . . "The great thatched barn, the red roofed malt-house, the oast with its inquisitive cowl, the wind-mill, the water-mill with its little cascade and sleepy pool, the lime kiln, the village pottery, the smithy, the shipbuilders yard, fragrant with tar and clamourous with the ring of mallets, the harbour crowded with barques and brigs, the black timbered sail lofts, the mast house, the great quay-capstans, jib cranes and whipping stages—all were picturesque and comely." Mr. Freeman romanticizes, perhaps, but we have to agree with him if we have seen High Street in

Newburyport, or any New England village green which has preserved its ancient outlines.

Then the deluge broke, and deposited sprawling factory towns and the long strip sores of railroads over the countryside. Coal and iron mines scarified the wilderness; harbours were filled with rusting coasters, coal piles, and old metal dumps. Finally came the automobile to line the highway with acneous eruptions of hot dog stands, bill boards, filling stations, antique shoppes, Come On Inns, and lately with the rusting bones of internal combustion engines which have panted their last. (Just what are we going to do in America with the corpses of the 10,000,000 motor cars which are marked for early extinction?)

One exception must be noted. The symphony orchestra made its bow to the world, arm in arm with the first power-driven factories. It flourished and grew strong along with looms, locomotives and milling machines. As I sit in the gallery at Carnegie Hall with half-closed eyes, watching the uniform flash of silver bows over uniform white shirt fronts, the answer to this riddle drifts into focus. What is an orchestra but a cunningly articulated, and thoroughly standardized, factory of sound? Then as I sample the waves which reach my ears, and compare them to the currents from a rolling mill—the answer drifts out again. Perhaps music was the spar which saved the race from drowning through all those dreadful early years.

Brooklyn Bridge was the first demonstration that the machine itself could produce a great work of art. It was a perfect expression in line and mass of all that the structure demands from the engineering element, and of all that the eye requires in their disposition—to use Mr. Mumford's words. Completed in 1883, it demonstrated that modern architecture should operate within the technological limits of the engineer; should frankly recognize his mechanical design, and by colour and mass express it, rather than covering it up with Doric columns and cornucopias of cast iron.

Since 1880, the often bilious eye of even Mr. Mumford recognizes a revival in painting, typography, textile design, furniture, architecture, and the principles—if not the practice—of city planning. The pall of smoke began to lift for factory workers about this time, and it rose too from things aesthetic. Today we are beginning to discover, considerably to our astonishment, and in the teeth of stiff opposition, that the machine killed one age of art only to give birth to another. What we have gained to date is, in my opinion, far short of what we have lost. Nobody with eyes in his head would prefer Chicago to Nuremberg for an unchanging visual diet, or the Albany Post Road to a Roman highway. But the comparison is purely academic, for Nuremberg remains static, while one has difficulty in recognizing the Chicago lake front from one year to the next. And year by year, its beauty gains on its ugliness. The real point, then, is not what we have gained to date, but what we stand to gain over a respectable historical period. For all I know, I shall go shouting into my grave, in the knowledge that the erection of bill-boards has been made punishable by the rack and thumb screws. For all I know, the sleepy tides may then be rolling over what was once Manhattan—an island which decided it was overburdened, and calmly sank.

The most impressive exhibit in the rebirth of art is of course the skyscraper, a pure machine creation. It consists of a steel skeleton made to mass production, hung about with a curtain of brick. The walls keep the cold out and the heat in, but they sustain nothing. The structure, moreover, could neither be built nor lived in without a machine operating in its esophagus—the elevator. The early skyscrapers were imposing by virtue of their size, but hardly for their surfaces. The architect had not learned to come to terms with the engineer. He scrawled them over with cornices, columns, bad Gothic and worse Byzantine. In New York one may see a Greek temple sitting most uncomfortably five hundred feet above the street—like Apollo on a barber pole.

But the neo-classicist architects were old, and happily they began to die. The younger men realized that they faced a totally new problem. More and more they came to respect function, and less and less, tradition. "The result is inevitable. Ornament is disappearing. It is uneconomical; it is often unsuccessful. . . . Architects of future big buildings will create their effects exclusively in mass, while decoration will be almost entirely limited to colour."

We have here a pretty illustration of the technological limit discussed in the last chapter. When the skyscraper is treated for what it is—rather than as a Greek temple or a Moorish palace—when its diminishing mass and vertical lines are made the basis for architectural treatment in ascending, breaking and ascending perpendiculars, flat or fluted, we have an authentic work of art. When we cover its surface with factory-produced ornaments in stone and metal we are outraging the technological qualities both of the structure itself, and of the machine as an adequate worker in plastic decoration. This double negation made our early steel buildings the monstrosities they were, while the double affirmation will make them increasingly beautiful tomorrow.

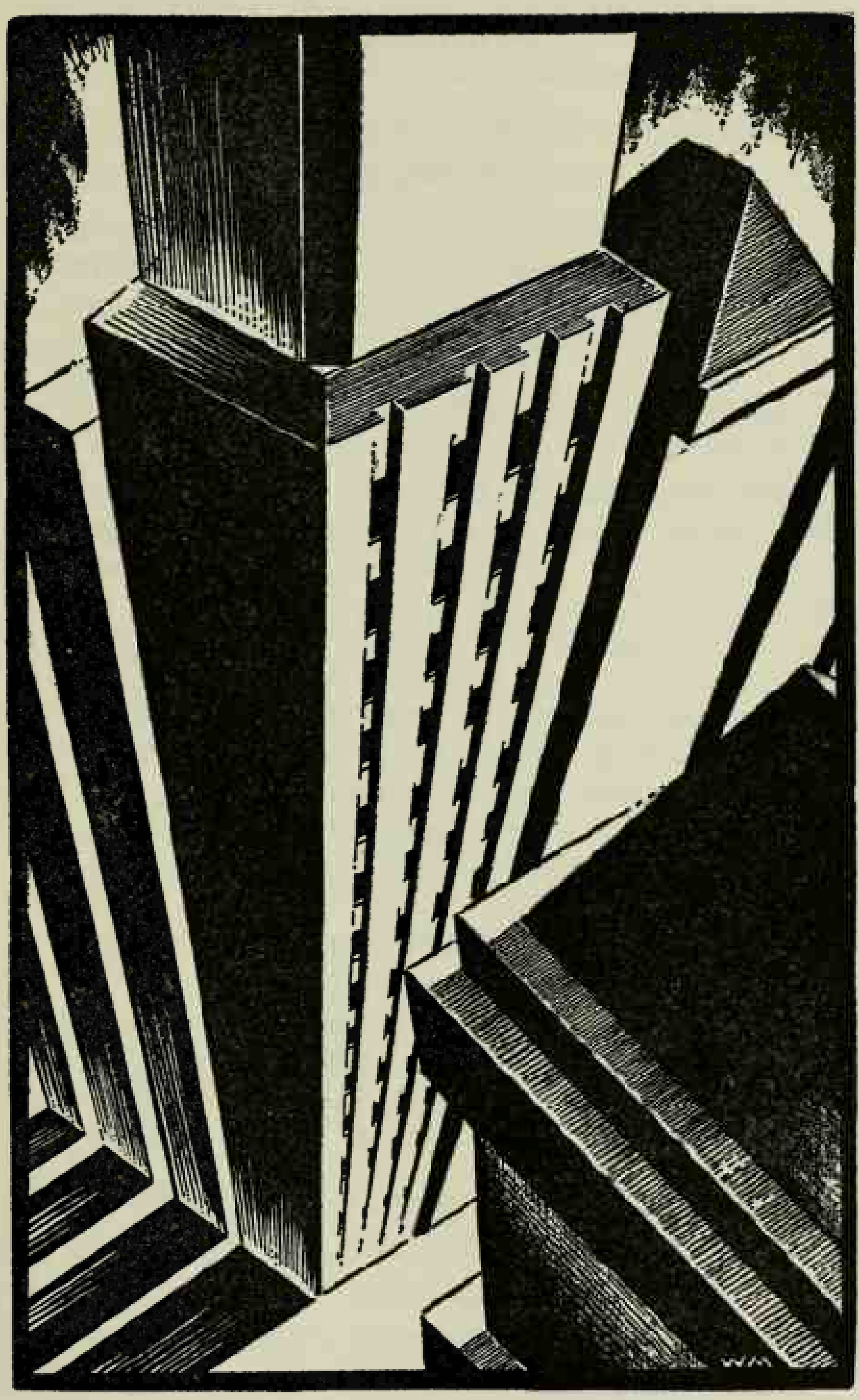
Lovely many of them are today. The only trouble is that one has to charter a liner or an airplane properly to admire them. I work at the foot of a whole new group of skyscrapers clustered about the Grand Central Station in New York. I have been advised, by gentlemen whose artistic judgment I respect, that some of them are very beautiful. This may be true, but I have never seen these buildings. I see their flanks and thighs; I note their doorways, but their heads I have seldom glimpsed, nor has any man alive seen the whole body at once. They tramp on one another's shoulders, shut out one another's vistas; while, lacking any open space about their feet, not one city dweller in a thousand properly realizes that they are there. We have developed no horizontal art of city planning to give perspective to the perpendicular art, which—it is alleged—is banking up amidst the clouds.

Thus the great city not only wastes labour, but builds its choicest aesthetic treasures primarily for the inspection of seagulls. "The new cities of the Western World are not organic centres but inefficient mechanical agglomerations." Technology demands not more complications, but simplification in the form of parks, open spaces, radial boulevards, perspective, sun, air, light. In such an environment, the machine can really function, and give us an architecture of such towering loveliness as to make the heart falter in its beat.

An interesting contribution to painting has been made by the camera. Heretofore the energies of many great painters—such as Rembrandt—were given to portraiture. All too frequently the subject was rich but uninteresting. Nowadays our leading bankers and merchants can be enshrined to perpetuity by handsome cabinet photographs in as many poses, and with as many striking side lights, as they please. This operates to relieve the painter of his dull, if ancient, task, and permits him to employ his talents upon subjects which interest both him and the rest of us more. At the same time many photographers have themselves turned artists, and with their machines are giving us not only memorable portraits, but charming and lovely studies in every field. A New York photographer has even made the elevated railroad endurable by photographing the patterns of barred sunlight which the structure throws upon the street.

Meanwhile it is gratifying to learn that there has been a strike of the worm-hole borers in an Italian factory dedicated to the mass production of antiques. It is not so gratifying to read the headline: "Artist Aims to Be the Ford of Statuary." It is not so gratifying that sales of pianos are steadily declining before the onslaughts of the phonograph and radio, thus turning active performers into passive listeners. Possibly to compete with the radio salesmen, a machine has been invented for teaching the piano. An instructor plays a control instrument and as he hits the notes, an electrical contact is made with a score of pupils' pianos, whereby little white and red lights flash just above their keys. Manfully the children strike the lighted key, and so play in exact replica to the instructor.

Mr. Robert Brady has worked out a theory of the interaction of the machine on art which is worthy of consideration, even if some of its ramifications need further study. "The characteristics of the machine from the artists' point of view, stress the visual expressions of mass, size, speed, fleeting images, repetition, sharpness of line; oral experiences of the staccato, precise timing, and rhythm of completed operation—sharp and high key noises definitively separated from the


WM

underlying matrix of monotonous and undifferentiable sound." Following these laws, he notes:

> Cubism and futurism.
>
> Stream-line bodies for motor cars.
>
> Modern plane and angle furniture, skyscraper bookcases.
>
> Color combinations in factory plant equipment.
>
> Jazz.
>
> The studied dissonance of Carl Sandburg and Vachel Lindsay.
>
> Journalese. "If the mass must read, they must read on the run with no thought-gap between the written word and its photographic likeness."
>
> The phenomenon of record breaking. "Everything is longer or shorter, thicker or thinner, faster or slower, bigger or smaller. Daily the records fall—long distance swimming and dancing, coffee drinking, the times of all the trips by all the known methods of travel between all known geographical points, heights of buildings, stock exchange sales, college enrollments, income tax aggregrates, flag pole sitting, continuous piano playing."
>
> The steady migration of economics, philosophy and psychology into the laboratory.
>
> The new theatre, and its scenic effects. (In Russia, in 1927, I saw a thrilling ballet, in which dancers clothed in black and silver stylized the motions of great machines.)

Enough has been said to make it evident that the case of art is not hopeless in the Power Age. Many new arts have come to birth; skyscrapers, lordly engineering structures in cement and steel, the curve and sweep of motor highways, photography, the moving picture (when out of the hands of sometime pants manufacturers), stage setting and lighting, the design of automobiles, airplanes, ocean liners, and a great variety of mechanical products, fabricated within their technological limits, and as perfect and lovely, in their own way, as a Sheraton chair in its. New skills have been developed to serve these new arts, and both represent a definite and extensive addition to the world's aesthetic store.

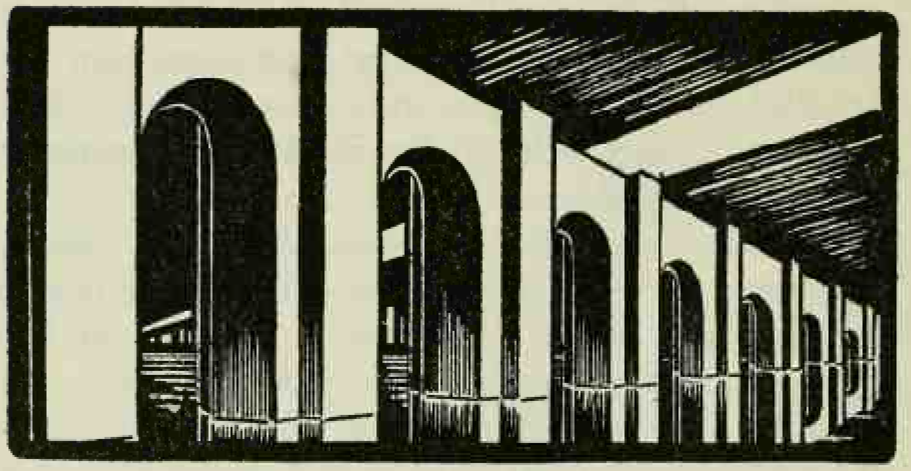
In attempting to imitate many of the products of the hand worker; particularly painting and sculpture, the machine has failed. Despite the efforts of the gentleman who aspires to become the Ford of statuary, I believe that the recognition of that failure is a matter of common knowledge, and that increasingly the machine will be encouraged to repose on its own side of the bed. Meanwhile a gorgeous tonnage of bric-a-brac, funeral urns, and elegant scroll work awaits the torch and the axe.

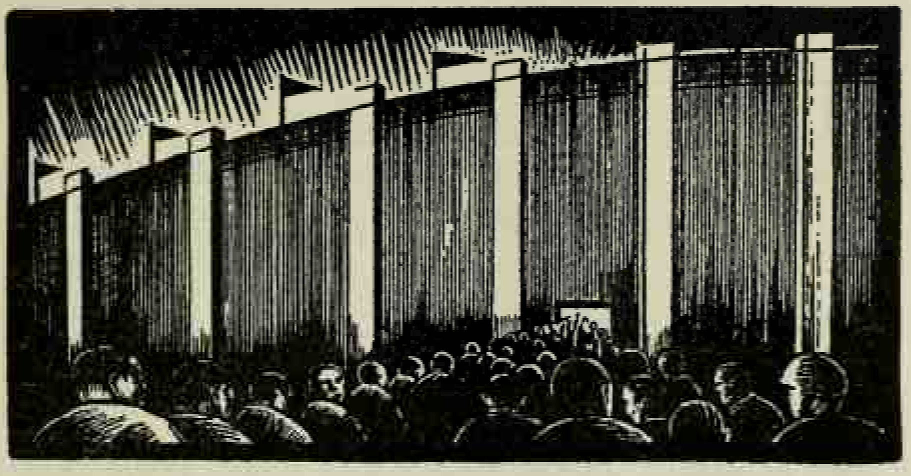
Finally, the whisper has gone around the business world that there is money in aesthetics. Ford, after saying that he would not give five cents for all the art on earth, is flirting with antiques. There is a new emphasis on design in the metal trades; kitchens and bathrooms are beginning to glow; gas stoves are for sale in red, green and blue; there are furnaces with coloured enamel casings; and on the Reading Railroad is a purple locomotive. Much of this has about as much to do with art as has a cow with the calculus, but there is no doubt that many business men are eager to pay well for good designs which express the age in which we live.

One sad aspect of the traffic, however, is the seduction of artists by salesmanship. (Where is the house not haunted by this ghost?) Designers may work in this field without irreparable damage, but whenever a promising painter, sculptor or writer, begins to use his talents for a brisker turnover in soap, teaspoons and silk stockings, the world stands to lose an artist, even as the bank stands to gain a depositor. In the past generation, scores of genuinely talented men and women have gone down into the jewelled cabin, never again to be seen on deck. That they have improved the quality of advertising matter is not to be gainsaid.

Architecture, painting, sculpture, music, the theatre, literature, structural engineering, design—not one is languishing in Western civilization. You may not like the output either in whole or in part, but you cannot deny the vitality which permeates the exhibit. And in the last analysis is it not better to be imperfect but alive, rather than perfect and dead—as was the art of the later Egyptian dynasties, where craftsmen were content to copy old designs?

Two great wounds are still unhealed. Save possibly for the machinist, nothing has been done to bring back to the common man the arts which the machine took away from him, and which formed so vital an element in his daily life. Little has been done in the planning of towns and cities to meet the technical and aesthetic limits of the age of power. The first is an authentic count against the machine, one of the most grievous that all this exploration will have to record; the last is but another exhibit in the stupidity of man.





CHAPTER XIV

PLAYGROUNDS

BEFORE the days of the bicycle, play in a New England town has been thus described by Mr. Benton MacKaye. I can still remember happy vestiges of it in my own boyhood in Massachusetts.

> There was the swimming-hole in the mill stream—and the flooding of the meadow for skating around the evening bonfire. There was the "after haying" picnic on the river intervale, and the "double-runner" coasting parties by February moonlight. There was baseball and shinny; rainy day "pout" fishing and tracking rabbits. There was the mud scow on the spring meadow—and there was fishing through the ice. There was the illustrated lecture, on the stars or on the Norman Conquest. There was *Evangeline* read aloud on a long solstice evening; May baskets on twilight doorsteps with loud knockings and merry routs of conquest; there was "drop the handkerchief" on the Common. There was the strawberry festival on the green; the corn husking on the barn floor. There was the Grand Masquerade in the January thaw—and

quadrilles and reels and slides. The church bells rang out on the night before the Fourth (with the parade of the Antiques and Horribles to come), as the sleigh bells did on the night before Christmas.

With variations due to local customs, this picture might hold for all of America, outside of the big cities, in 1875.

On a summer Sunday in America today, people also play. Some forty millions of them are being carried by a machine at thirty miles an hour, past Goodrich Tire signs and Travelers' Rests; and anon creeping in single line at one mile an hour to the escarpments of bridges ferries, tunnels, and bottle-neck highways, in a steamy sweat of oil and dust. Millions are eating the inevitable steak or chicken dinner at the inevitable blowsy road house, while the gin gurgles into the Canada Dry, the radio drowns the engulfing of the canned tomato soup, and Jim and Ethel essay the Black Bottom. Ten millions are seated in the dark watching a personable young woman alternately mislay and recover her virtue for six thick rolls of celluloid. For some hours of the day, practically the entire population of the Republic disappears under something in the nature of 60,000 tons of wood pulp, to the accompaniment of a noisy if not positively sanguinary struggle between the younger generation as to which has prior right to Mutt and Jeff.

Along the Atlantic, the Pacific, the Gulf of Mexico and the Great Lakes, stretch 10,000 miles of fine hard beaches, deserted save for the seagull, the sandpiper, and the crab. From point to point between the lonely stretches, to a total linear measurement of perhaps fifty miles, more millions congregate, each with his bottle of pop, his banana, and his cheese sandwich. Running and leaping is not seemly in such mass formations, but phonographs, embellished with a little sand, are always welcome. (Yet here and there in the last year or two, have I or have I not caught a glimpse of naked, sun browned bodies upon the lonely reaches?)

When the pop bottle and the banana peel have been duly deposited to add their quota to the littoral, there is more play to be had immediately to the rear. Here rise fantastic towers of white plaster, which, as twilight gathers, glow and sparkle with innumerable lights. Here tram loads of shrieking shop girls rush down frightful declivities; here may be viewed the fattest, the tallest, the shortest, the most convoluted of the species. Here one meets oneself with a resounding thwack in mirror mazes, is deftly bereft of equilibrium by spinning, heaving floors; loses hat and modesty by jets of compressed air. Here a five-dollar bill melts like the snows of April.

Fifty thousand are roaring as the Home Run King lifts a horse-hide pellet over a board fence; hot, disquieted matrons are reading confession magazines in stuffy parlours; unnumbered gentlemen, white and coffee coloured, snap their fingers and utter cabalistic cries over two small cubes of bone upon the floor; far into the reeking night in a haze of smoke, thin men sit in shirt sleeves bowed over pieces of cardboard and round, brightly coloured discs; while throughout the day five hundred thousand ampler men alternately strike and curse at a small white ball, magnetically attracted to pits of sand, or if there is no sand, to pools of water.

All that remains of Mr. MacKaye's tradition is the small fraction of the population, who, with knapsacks on their backs, and maps in their hip pockets, are to be found here and there clambering over hills and mountains, or striding back country roads, too rough for any vehicles save the surviving buggies and an occasional reluctant Ford.

Recreation may be defined as creating again in play the balance that has been lost in work. *Decreation* is compounding the lost balance through unrewarding forms of play. A great fraction of this modern Sunday scene is decreation, and much of it is clamped to the machine. I have elsewhere roughly estimated the total annual cost of all forms of play and diversion in the United States at twenty-one billions of dollars—not far from a fourth of the national income. About one-half, or nearly eleven billions, is spent for diversions impossible without machinery, as follows:

Pleasure motoring (2/3 of total motor bill)	$5,000,000,000
Vacations and travel (primarily the transportation element)	2,000,000,000
Moving and talking pictures	1,500,000,000
Newspapers, tabloids, light fiction (in part)	1,000,000,000
Radio	750,000,000
Phonographs, pianolas, etc.	250,000,000
Telephone—social factor only	100,000,000
Mechanical toys	50,000,000
Amusement parks (in part)	50,000,000
Flying and bicycling	25,000,000
Total	$10,725,000,000

The motor car, as has been the case with all our recent lists and tables, claims the lion's share. In the aggregate, it is the most powerful prime mover we possess; it is the outstanding exhibit in mass production; it is the rock upon which the whole structure of American "prosperity" is founded; it is the chief creator of the new labour burden; the mightiest reason for the congestion of cities and the desolation of the countrysides; and the leading national plaything.

We spend ten billions more for forms of play which are conceivable without machinery, but in which, as a matter of plain fact, machines play an important part, if only in supplying equipment and transportation. Nor is this theoretically non-mechanized field altogether a replica of the New England town of 1875. Tennis, boating, swimming, field sports, winter sports, camp ing, climbing, hunting and fishing, amateur or pre-collegiate baseball, football and hockey—are conceivably an honest extension of Mr. MacKaye's picture, but these are not the sports where the money is spent—they constitute only a tiny fraction of the whole ten billions. The real money is found in such recreations—or decreations—as road houses, night clubs, confectionery palaces, soft drink emporiums, hobbies and collections, shows and religious revivals, golf, tobacco, jazz palaces, speak-easies, the exchanging of holiday presents, horse racing, college football, professional baseball, and super-professional prize fighting. Perhaps the last word should be qualified, in accordance with the researches of Mr. John R. Tunis, who holds: "The modern pugilist is last of all a fighter. A lecturer, and endorser of belts, underwear, shaving cream and storage batteries he must be. An apt speaker on the radio, a handy man with his pen when contracts are being flourished, knowing in the art of obtaining publicity—these are the gifts which must be cultivated by the pugilist of today. As he will need to contest on an average but one bout a year, his ability in the ring is of far less importance."

In respect to the total number of Americans who now engage in some of these diversions, mechanical and otherwise, I have prepared the following table:

Newspapers and tabloids—35,000,000 circulation a day.
Radio—30,000,000 listeners a night.

Phonographs, player pianos—15,000,000 listeners a night.
Moving pictures—50,000,000 admissions a week.
Theatres, concerts, shows, popular lectures, revivals —5,000,000 admissions a week.
The popular magazines—15,000,000 readers a month.
Professional baseball—40,000,000 admissions a year.
Football—20,000,000 admissions a year.
Horse-racing—10,000,000 admissions a year.
The pugilistic industry—10,000,000 admissions a year.

In 1927 four million people paid to witness sporting events (with apologies to Mr. Tunis), at Madison Square Garden in New York. A single game of football or baseball may require the printing presses to turn out close to 100,000 tickets.

All these figures serve to drive home one cardinal point. As a people we tend to take our diversions second-hand. In Middletown "the leisure of virtually all women and of most of the men over thirty is mainly spent sitting down"—in a motor car, at the movies, reading, or listening to the radio. A few play—or better work—on gridiron, race track, diamond and prize ring—while the rest of us shout, clap hands, hurl pop bottles at the umpire, crush in our neighbours' hats, and get what thrill we may from passive rather than active participation. Our play comes to us, in these circumstances, at one remove from reality. When we watch a score board outside a newspaper office, it comes at two removes. This was not the idea in the New England town; indeed, save for the Coliseum of Imperial Rome, it has never been the recreational idea of mankind. Down the ages we have watched and listened at theatres, bull fights, concerts, but how small a part it has been of the total play activity. Today it is the larger part, and I suspect the ratio is increasing—despite the new golf players and the campers.

Among nature people—and happily among our own children still—play is active participation in the dance or game, in which muscles, voice, senses, rhythm, are all involved. As often as not, it is linked to work, and linked to art, and develops as an integral part of the whole personality. Not for nothing did Havelock Ellis, from the profundity of his understanding, write *The Dance of Life.* Not for nothing has the folk dance been close to the heart of every nation in history. If we come to life as earlier cultures came to the dance, we live; and when the dance dies, or hardens into jazz, the flame dies with it.

I would argue for no return to the sports of New England, nor for any conscious attempt to set up national folk dances, simply because old England had her May-pole, and the aborigines their fire dances. Mr. Ford, encouraging turret-lathe operators to perform quadrilles, has embarked upon a pathetic and futile quest. I argue only for the spirit of the dance, the letting go with mind and muscle in play activities which give release to timeless biological patterns, and so bring rest and peace.

For tens of thousands of years, ancient man lived by big game hunting. When he settled down to cultivate the soil, he found himself with duller work; many modern occupations are duller still. The lure of the older pattern still survives, and demands expression. I believe the facilities are now available to give it expression; and not only believe it, but practise it. Many of us find genuine—and cheap—recreation in such forms as:

- Mountain climbing
- Canoeing
- Trail building
- Swimming, diving and sunbathing
- Skiing, skating and snowshoeing
- Amateur acting
- Group singing
- Golf and tennis (in season)
- Yachting and fishing
- Gardening
- Handicrafts as pastimes—carpentry, metal working, amateur photography
- Home decorating and painting
- Amateur botany, geology, ornithology.

Such play is primarily non-mechanical, and while I should be the last to hold that it ought to displace motoring, the movies and Coney Island *in toto,* a judicious admixture with the mechanized structure is certainly advisable. There is just a chance that these true recreations may win out in the teeth of the commercial drive in the opposite direction. Automobile camping has succeeded in luring millions to spend a night or two under the stars, and the habit may grow. The development of national and state parks is very encouraging. The fact that some 850,000 city children in America are now learning real recreational habits in work-study-play schools is encouraging.

Here are, however, the most frequent play forms of fifteen-year-old boys and girls, as compiled by Messrs. Lehman and Witty in a recent survey of 7,000 Kansas school children, town and rural. They are arranged in order of frequency.

Boys	*Girls*
1. Reading funny papers	1. Reading funny papers
2. Other reading	2. Other reading
3. Playing catch	3. Automobiling
4. Automobiling	4. Playing the piano
5. Going to the movies	5. Going to the movies
6. Playing baseball	6. Writing letters
7. Watching sports	7. Playing the phonograph
8. Playing football	8. Visiting
9. Listening to radio	9. Gathering flowers
10. Playing basket ball	10. Singing
11. Wrestling	11. Teasing somebody
12. Bicycling	12. Looking at photographs and pictures

Of the twelve most frequent forms for boys, six are participating, six are second-hand, while six are closely linked with machinery. Precisely the same ratios hold for the girls, except that they exchange the radio and the bicycle for the phonograph and piano.

Reading ranks second in both lists—which gives us occasion for a philosophical digression. Plato once wove a little allegory about the discovery of letters. Said the King God Thamus to the inventor: "This discovery of yours will create forgetfulness in the learners' souls, because they will not use their memories; they will trust to the written characters and not remember of themselves . . . they will be hearers of many things and will have learned nothing; they will appear to be omniscient and will generally know nothing; they will be tiresome company, having the show of wisdom without the reality." Using this as a text, Mr. Waldo Frank notes that our daily news in America gives us a thrill, but we learn nothing from it. "Truth papers" would tie news to its whole philosophical content—the background of history, biology, science, art. "Newspapers" serve up single dramatic isolated phenomena—murder, divorce, scandal, adventure, flight, disaster. We are deluged with isolated facts presumably true, but we do not grow in wisdom, rather the reverse.

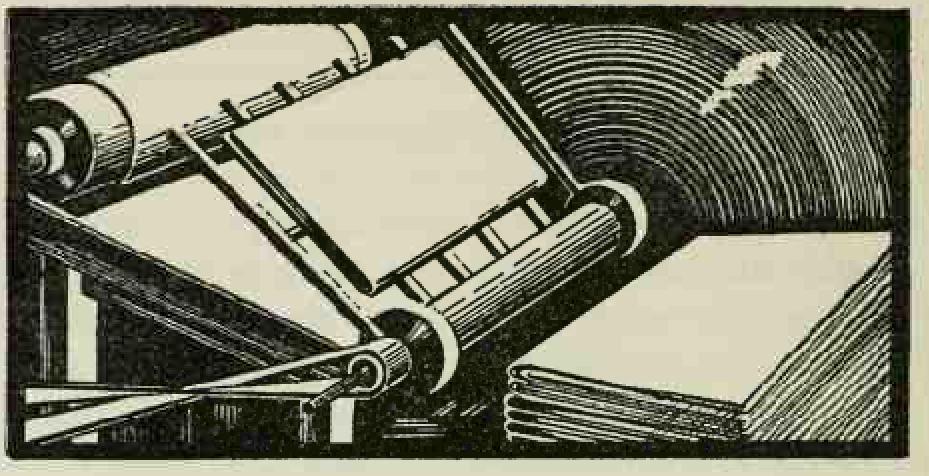
In our analysis of robots, skills, the flood of goods, and even art, we found that the gloomy prophets, never troubling to look below the surface, had tended grossly to overstate their case. There was much that was depressing, but the hopeful elements were also many. In play, however, we have struck upon a vein of pessimism that is difficult to disperse. Americans are the chief proponents of the machine, and they are not a happy people. The fact that they are restless, nervous, at odds with their world, and frequently depressed, does not need to be argued. Look at the faces in the streets of any city. Play is the flywheel of life, and America, with the most stupendous recreational equipment ever dreamed of, does not know how to play. It can only step on foot throttles, insert coins in metal slots, scan headlines, crowd through clicking turnstiles, rush headlong down roller coasters—seeking a balance which these things can seldom give.

This is the more tragic, in that the specialization and frequent monotony of our daily work, however skilled, clamour for psychic equilibrium. We ought frequently to take to the woods and utterly abandon machines in our hours of leisure, but instead we compound the mechanisms of shop and office with eleven billion dollars worth of play machines. Yet when one considers the vast forces whose capital is staked upon so many million paid admissions, so many mechanical devices marketed per annum, so many copies of sporting extras sold, it is difficult to see how the weights are ever to be adequately adjusted. It ought not to be hard to persuade our fellow citizens to have far more fun for far less money; but who, knowing the strength of the current commercial structure, has any hope of a successful campaign based on such obvious common sense?

Rather I would agitate for two cars and three radio sets per capita. In the midst of that unbelievable congestion and devastating racket, the entire nation on some bright morning might flee—cursing and praying for deliverance—into the mountains and the wilderness. . . . Provided there was any wilderness left to which to flee.

The prophets of doom have a final point to make, which they cannot prove—nor anybody else for that matter—but which fills me with an uneasy suspicion. They argue that all the talk about the shorter work day which is to give the robot opportunity to balance whatever psychic losses he may have experienced in the factory, is nonsense. The factory, they declare, has so conditioned the worker that he has *lost the very faculty of playing.* More free hours will simply mean more gasoline, more bleacher seats and more speak-easies. Work and play must move in some sort of integrated balance. If you kill the instinct of workmanship, the play instinct is also killed. Thus the uplifters who are proclaiming that the five-day week, or the five-hour day, is to solve all the psychological difficulties which flow from modern industry are arguing for a lost cause.

I am afraid that this sounds like a good preliminary case. It may well be that the genuine robot has ceased to be a human being in any complete sense, has forgotten how to play, and that more leisure will never do him any good—may even do him ill. But as we have seen, the genuine robots can hardly exceed five per cent of the population of America, and under the growth of automatic machinery, this ratio is probably declining. If the remaining ninety-five per cent can somehow break through the commercialized amusements which now encircle them, the outlook, bitter as it might be for the robots, would not be hopeless for mankind.



CHAPTER XV

ONE DEAD LEVEL

THERE are many machines in Western civilization. There are many standard behaviour patterns. It is argued that there is a connection; that machinery is standardizing human life. There are practically no machines in China, while behaviour patterns are so rigid that they have persisted with little change for four thousand years. Here is an even stronger connection—save that it is upside down.

The Jeremiahs, notwithstanding, have prepared a moderately impressive exhibit. The machine-made character of George Folansbee Babbitt has been set before us in immensely documented detail. Mr. H. L. Mencken delivers one hundred pages of additional material every month. Mr. Sinclair flings the *Goose Step* at our heads. One distinguished foreigner after another visits the assembly line of Mr. Ford, and a Rotary Club at its luncheon ceremonies, and from thence departs on the next liner, impatient to put upon a rotary press one more volume announcing that machines are reducing Americans to automata. While many thoughtful native philosophers, with plenty of time for observation, are, like Mr. John Dewey, disturbed at what seems to be a growing regimentation in social life—the stamping out of local traditions, local colour.

> They are our last frontier.
> They shot the railway-train when it first came,
> And when the Fords first came, they shot the Fords.
> It could not save them. They are dying now
> Of being educated, which is the same.
> One need not weep romantic tears for them,
> But when the last moonshiner buys his radio,
> And the last, lost, wild-rabbit of a girl
> Is civilized with a mail-order dress,
> Something will pass that was American
> And all the movies will not bring it back.

Thus Mr. Stephen Vincent Benét chronicles the passing of the Kentucky mountaineer, and brings five specific mechanisms into his bill of charges.

Columbia University is now preserving for posterity twenty-four varieties of American dialect. Last, lost ancients from Kentucky, Cape Cod, tall cotton and low cotton areas, are talking into phonographs that their inflections may be permanently pickled before it is too late. (Thus one machine attempts to salvage the ravages of its brothers.)

A very keen student reports that Main Street is now importing practically all its thinking from large central thought-factories in the cities. Boiler-plate editorials have replaced the sometime salty comments of the local editor. The inculcation of thrift, the proper thoughts to be held in respect to the credit structure, investment and financial success, are all set forth in neat pamphlets to be found beside the deposit slips on the local banker's counter, and all duly forwarded to him by the publicity bureau of his trade association, with offices in New York. Even the churches hang out weekly shingles on the temple lawn, the mottoes for which are prepared, engraved and shipped by a religious service bureau (willing to take any creed as client). As for the manager of the local chain store, he can scarcely move a can of peas from one shelf to the next, unless guided by a chart from the central office.

The Committee on Public Information during the War provided us with the supreme example of the attempt to standardize opinion by propaganda; an example which not even the spirited drives of Old Gold cigarettes and Lux toilet soap can equal. Seventy-five million copies of thirty different booklets, printed in many languages, were circulated throughout the United States, and millions of additional copies abroad. Seventy-five thousand "four minute men" made 755,190 speeches in 5,200 communities, explaining the proper philosophical alignment of the words "democracy" and "war"; and the principle of giving until it hurts. Save for a few duly incarcerated objectors, the nation acted as one man.

This alleged levelling down moreover does not apply to the United States alone. Mr. W. Redpath-Scott, writing in the London *Daily Mail,* notes that a generation ago it was fairly easy to guess a man's occupation by his appearance. Now the silk-hatted city clerk is as rare as the smock-wearing farm labourer. The horsey-faced hostler has given way to a garage man, with just a face. John Bull landlords with rosy gills are hard to find. Where is the Durham miner with his shiny black broadcloth and queer little round tasselled cap? Where is the shawl of the Lancashire mill girl? Where is the navvy with his white felt hat, velveteen coat cut square, spotted waistcoat and blackened cutty clay pipe? Only his kerchief, and that more subdued, survives today.

The London *Evening Standard* holds that all Western peoples are beginning to look alike. "It is only when he opens his mouth that it is possible to tell that a man retains a nationality of his own." Class distinctions are disappearing by virtue of cheap imitations of costly attire. The duchess looks like the coster girl. Designers and beauty specialists are enforcing one type of figure. Where are the noble curves of yesteryear? "No matter where one goes, in the richest quarters or the poorest, in Wales or in Saxony, one sees the same small, tight hats, pulled down on shingled heads; the same short, straight frocks and light-coloured stockings." The root of this uniformity is found by the editor in the camera. "All the world sees with the same eyes, and what it sees often multiplied, must influence the whole of its life. The cinema and the illustrated papers broadcast fashions, as no fashion was ever broadcast before." Beginning with clothes, this international uniformity is spreading to food, games, dances, amusements.

One could quote this sort of thing indefinitely, until a case of the first magnitude had been compiled to prove the regimentation of Western peoples. Nor am I disposed to doubt the general outline of that case. But certain additional questions are in order before any final conclusions can be drawn. Is the machine primarily responsible for this regimentation? Is it more drastic than the regimentation enforced by the *mores* in other civilizations, or among nature peoples? Are the forms which it enforces better or worse than other historical forms?

The fact of culture, of group living, implies standardization. It always has; it always will. Human beings submit well to the process. Standards change, but standardization remains a perpetual element of all societies. There is nothing, therefore, in the word itself to alarm us. The machine has certainly helped to cast our present mould, but it has not created the phenomenon. Nor, as I believe I can prove, has it enforced nearly such rigid standards as those promoted by ancestor worship in China; the Church in medieval Europe; the economy of the cocoanut, maize, wheat, or fish among peoples depending primarily upon these foods;

the caste system of India; the state socialism of the Incas in ancient Peru; and a score of other agents which might readily be named. One of the outstanding facts governing a machine culture is its restless and remorseless change. Look again at the table of inventions in Chapter IV. Every item on it called for a reorientation of the habits of great numbers of men and women. Look at the terrific shaking up the automobile has given us. Look at the enormous turnover in styles and fashions caused by too many machines in the textile industry. Machines create standards only to destroy them again.

In China, India, Samoa, standards crystallize century by century. A man hurled forward ten generations would find a world substantially unchanged. He could pick up his work, his love affairs, his marital arrangements, his religion, his games, with no astonishment and little effort. But imagine my grandsire of the tenth generation stepping into my shoes today. Even my grandfather used to shake his head sadly and ask what the world was coming to. Standards were changing faster than he could adjust himself to them. He would never read a magazine until he had first cut out all the advertising pages and thrown them into the fire.

Look at the fads which follow one after another in crazy procession—bicycle riding, ping pong, golf, bridge, mah-jong, jazz, crossword puzzles, bobbed hair, antiques, prohibition cocktails. Look at the steady drift from the farm—where the *mores* have ever been powerful—to the cities—where they were always more tenuous. I repeat that the machine is probably the greatest destroyer of standards since the Goths sacked Rome.

Why, then, does one admit a case for modern regimentation? First, because regimentation is always a social fact; and second for a reason which I think is cardinal to the whole discussion. Because the machine has destroyed so many of our habits with a devastating thoroughness, we have been left a people lost in the wilderness, our time-honoured folkways scattered and dispersed. Such a thing is culturally unheard of, and obviously intolerable. So, in a sort of frantic desperation, we have created one set after another, mainly temporary and not binding—in the sense that the corn-seeding ceremonies were binding—but at least serving as hand-holds for men who had lost their cultural balance. Like all temporary construction, they tend to be lopsided, ugly and colourless. We have standards; we do kneel by the million before them, but as long as the highway world of today becomes the air world of tomorrow, the mixture continues plastic, refusing to harden—as the ancestor worship of the Chinese has hardened. And I think it might be argued with some cogency that standards which do not last the season out—metaphorically speaking—are nothing to be genuinely afraid of.

The varieties of standards are endless, but three great groups may be identified to make the discussion more concrete.

First, we may note technical standards for the use of science and for the operation of industry—the simplification and standardization movement.

Second, commodity standards—the extent and variety of goods in a given culture; and how far such goods may be taboo for certain social classes.

Third, social standards governing behaviour patterns—the *mores* of sex, the family, worship, eating, drinking, playing, money, war, trade, work; together with the proper mental attitudes to be held concerning these things.

Industrial standards

We have a great number of technical standards for science and industry, many of them relatively permanent, and many of them excellent. Mr. A. W. Whitney has developed a philosophy of industrial standardization, using an apt biological parallel. Nature, he says, continually experiments with new varieties and forms, and then, through natural selection, standardizes the most efficient. If nature had no mechanism for fixing and holding the type, she would have no way of capitalizing her discoveries. Standardization is thus a liberator, relegating the problems already solved to their proper place, namely, the field of routine, and leaving the creative faculties free for problems still unsolved. "Standardization from this point of view is thus an indispensable ally of the creative genius," akin to the reflex centres in man and animal which automatically guard the organism, leaving the mind free for more unique and experimental activity.

When, after a long period of trial and error, an efficient and economical way to make automobiles, steel girders, or sauce-pans is evolved—then crystallize the process in mass production, manufacture the commodity according to standard routine, and set invention free. Two obvious dangers must be faced: first, going into mass production before the time is ripe; and second, selecting commodities for mass production which are ugly, dull, or of poor quality. Modern industry has repeatedly fallen into both of these pitfalls, but this constitutes no argument against the formulation of standard practices as such. The point would seem to be that if one has a good product, the technology for the production of which is advanced—with no drastic new invention balancing on the edge of tomorrow, and threatening to scrap existing methods—let him go into mass production, and mankind will be the gainer.

The sorts of commodities which are ready for this treatment today include:

Typewriters
Bookkeeping machines
Calculators
Cash registers
Agricultural machinery
Motor cars (except de luxe models)
Boots and shoes (average grades)
Hardware
Electrical appliances

In addition to mass production, there are many other industrial standards which, if carefully thought out, can only result in social benefit. Here are twenty-three Safety Codes compiled by the American Standards Association. They include adequate lighting for factories, the safe operation of elevators, protection for the head and eyes of industrial workers, the prevention of dust explosions, safe methods for window washing in office buildings, the operation of machine tools, mechanical refrigeration, conveyors, cranes, hoists, and even, if you please, a Safety Code for amusement parks.

What is the objection, Mr. F. J. Schlink asks us, to standards for *units* of length, mass, time, temperature; to standard *sizes* for screw threads, bolts, nuts, invoice forms; to the *definition* of a horsepower, a speed *rating* for locomotives; to *specifications* for cement, paint, cold-rolled steel bars, the fat content in milk; a standardized *method* for the erection of a steel bridge?

Standards are cardinal in science and technology; they are implicit and often excellent in mass production. It is a waste of time to argue the bogey of one dead level in this category. Any specific project—say the mass production of airplanes before the technique of safety has been achieved—is, of course, subject to argument. (And in this case, one hopes, adverse decision.)

Standards for commodities

We now leave the factory, and examine the articles which the factory is producing. As good a starting point as any is the Sears Roebuck mail-order catalogue. It contains over 100,000 separate items, and 36,000 different kinds of things. What other culture has ever provided such an exhibit? Where a well-to-do Chinaman in the time of Confucius might have his choice among a thousand articles, more or less, the well-to-do American has the whole mail-order list to choose from, together with probably a great number of items not comprehended in the list but purchasable elsewhere.

These goods furthermore are not limited to classes. Anyone may buy who has the money—billionaire, duke or scavenger. Anyone may climb out of his social group, if he has the money; and descend from Park Avenue to the gutter, if he has it not. There are no fixed classes in America, and this is becoming increasingly the case for the Western world. It is undoubtedly true that more people now dress alike, and look alike than they did a century ago, because of these dissolving class distinctions. But at any moment, men may leave off their black pants, and begin to sprout gaudy colours —of which I see the beginning already on Fifth Avenue. They are not confined to uniformity, as was the coolie and the medieval villein. Poverty limits and so standardizes commodities. Wealth expands them, and speeds up the fashion cycle into the bargain.

The most chromatic, not to say fantastic, experimentation is now going on in house decoration. New composition materials, new designs for skyscraper bookcases, bathroom fittings, playroom appurtenances—

appear upon the market every day. In New England most houses were once made to similar design. Now in any New England suburb you will find the century-old house with a Moorish palace on one side and a Spanish villa on the other. Every right-thinking suburbanite has of course his oil-burning furnace, his sleeping-porch, shower-bath, radio, davenport, garage, kiddies' room, open fire, electric refrigerator, and cocktail shaker—but the types and styles in which he may purchase these stark necessities are literally endless. While a new stark necessity is always being groomed in the stained-glass cloister of some advertising agency.

Main Street towns may all look alike, but one cannot be sure from one year to the next in what that likeness is to consist. They sprout traffic signals, stupendously upholstered policemen, banks in the shape of Greek temples, magnificent high school buildings, sparkling drug stores, batteries of columnar street lights, memorial libraries—practically overnight. While to keep track of the skyline of our great cities would require a swift airplane, perpetually on the wing.

"Things are in the saddle," and while they may be bought in million-unit lots, the choices of today are dead tomorrow; and to hold that our commodities increasingly seek a dead level is absurd. They seek altogether too many live, new levels; with the hand of the super-salesman always on the bellows. If this be standardization, make the most of it; but it is the standardization of infinite variety and perpetual change;

and thus uncomfortably close to a contradiction in terms.

Standards for behaviour

Lastly we come to standards for behaviour, and for mental processes. Are we machine peoples tending more and more to act alike and think alike? All that we can be reasonably sure of in advance is that behaviour, like the output of material commodities, is in constant flux. The machine, having destroyed many of our old folkways, has forced us to experiment with a host of new ones. We shall no more become adapted to thirty miles an hour on the ground than we shall have to take to the air at two hundred miles an hour. And what is *this* going to do to the family, religion, the etiquette of visiting and entertainment, recreation habits, education, relations with other races and other nations?

Letting the future speak in its own due time, the possible present varieties of behaviour patterns in the United States are legion; extremely difficult to fit into neat catalogues.

We have no standard religious code. One may take one's pick among two Catholic churches, more than one hundred Protestant sects, and heaven knows how many cults founded by prophets from the hinterland. If you rush up to a New York policeman and announce that you are an atheist, he will tell you to stop blocking traffic. You can have, in urban centres, One God, a whole pantheon, or none at all, and nobody—unless you are running for high public office—particularly cares. How far this is from the unified pattern of worship in the Middle Ages, with its ordered procession of masses, fast days, feast days, penances, celestial bookkeeping for every variety of conduct with debits and credits all duly balanced, and the bells of great cathedrals tolling over evening meadows, proclaiming their benediction upon the eternal unity of mankind.

If religious standards are in disorder, sexual standards are even worse. We may—in the more civilized centres—select orthodox marriage, trial marriage, companionate marriage, marriage of convenience, or no marriage at all. We may divorce almost at random. We may practise birth control in all circumstances, in specific circumstances, in no circumstances—with learned authority to sanction each decision. We are urged to have small families, large families, no families; to marry when young and poor, to wait until we are old and rich; to marry within our class, to marry above or below it. Nor is sanction altogether lacking for the advantages, cultural and economic, of a "sugar daddy." The psychoanalysts have lifted the curtain on a variety of matters long held suitable for discussion only in a brothel—if at all—and made them current coin at every "modern" dinner table. (In brief the only dependable standard in sexual affairs seems to be that any sort of reticence connotes a serious, not to say perilous, internal conflict.) HA HA

Education is in an equal fix. Children should be disciplined, they should be permitted to run wild; they should be sheltered, they should be exposed; parents are the ruination of them, what is so beautiful as mother love? Public schools are bad for them, private schools are worse, while tutors are the most pernicious of all. They should be taught to work, they should be taught to play, they should not be taught anything. All children are little Leonardos; all children are little animals. Every child should go to college; no child should go to college—let him accept a diploma in the university of hard knocks. In the centre of this chaos, the modern parent stands (I am one)—praying with whatever vestiges of the *mores* of worship he can summon, that somehow his child will survive his education.

As noted in the last chapter, we have no standards for aesthetics. The classical traditions of art have been undercut by the machine, but dying creepers still survive, entangled with thickets of cubists, futurists, vorticists, impressionists, and practitioners dedicated to the principle that prior to themselves there was no art. Meanwhile a struggle is in progress between first-hand and second-hand forms of play, with powerful forces pulling in each direction.

Our occupational habits may be regimented in detail, but as a total phenomenon they are infinitely various. No good American believes in the doctrine that his place is anywhere but at the top. Nobody stays, if he can possibly avoid it, in the place in which it has pleased God to put him. The ladder of success is crawling with struggling forms. Few ascend, it is true, but who has not rushed for a higher rung and missed? No man is fixed in theory, however much he may be in practice—which is the chief reason why the organized labour movement makes no greater headway in America. The result is a restless moving population, forever on the march to higher things—which seldom come; forever drugging itself with correspondence school courses (some ninety per cent of which are given up before the first lesson is completed). Drifting youths and men come storming into accountancy when it is held to be a new and lucrative profession; into California and Florida real estate when booms are on; into brokers' offices when stocks are going up; into the profession of bootlegging when pre-war stocks are going down. There is the constant migration from farm to city; the massive movement of negroes from the cotton fields to Harlem; while the variety of possible occupations—from deep-sea diving to flagpole sitting—is literally endless. The Lynds found over four hundred occupations in Middletown—a city of only 38,000 people. . . . How different from the medieval village in which one was born and lived and died; where no one ever left his class, but normally followed the trade of his father, and at best had hardly a dozen occupations from which to choose.

Many old behaviour patterns still survive, as we sketched them in Chapter VI, upon which the direct impact of the machine is slight. But the indirect effects of mechanization have shaken us loose from ancient mental certainties. We are never adequately prepared for change, and resist it when it comes, but we are beginning to realize with some bewilderment that almost anything may happen. And that mental attitude is slippery ground upon which to build a case for one dead level of behaviour.

I have, I believe, undermined the common assumption that the Western world is becoming rigorously standardized, by showing that on the contrary, its *mores* are in flux and conflict, while many of its institutions and most of its commodities are becoming ever more complex. Yet for all my arguments, the pictures of the Kentucky mountaineer with his radio, and the navvy, shorn of his velveteens, stubbornly refuse to fade. Local colour is going out of life. How can the argument and the fact be reconciled?

Western civilization comprises perhaps half a billion people. They are tending to build certain structures alike, dress on many occasions alike, think on certain matters alike. The same area a century ago was split into hundreds of communities, each with its own set of customs; its own arts and crafts. Now if we compare Western civilization as a unit today, with, say, Cape Cod a century ago, the latter is by far the more standardized community in respect to its morals, its arts, its behaviour. But if we compare the total area, now and then, the aspect of America and Europe was more unique and colourful, by virtue of the differing communities, one hundred years ago. The complaint as to standardization is usually made by travellers, and certainly a moving eye sees variety giving ground to uniformity at any given time period. But let the moving eye come to rest. Ask the traveller if he would prefer to live out his years in the Wales of the Eighteenth Century, or as a citizen of the modern British Empire? Unless he is an incurable sentimentalist he will prefer the varied life of the modern man to the limitations of the pre-machine man. . . . And put up with short skirts from San Francisco to Budapest as best he may.

But a last qualification is in order. We are not all free, roving citizens. Theoretically, the present choices before any individual are very wide. Practically, most of us never make these choices. We fall into a rut, and after a struggle or two, stay there. Taking the modern man in his rut, is he more regimented than the average individual in other cultures? This is a knotty question. The taboos and *mores* which guide him are not as stringent as among nature peoples; he has a far wider selection of commodities; but his day-by-day behaviour often tends to be more monotonous and dull. He has fewer vital things to do, fewer muscular adjustments to make, fewer things to think about. Here for instance is a comparison between a bookkeeper living in White Plains and commuting to New York, and a man living in a Samoan village today. A Park Avenue banker is also included for good measure.

COMPARATIVE ACTIVITIES

White Plains Clerk

- Bookkeeping
- Gardening
- Elementary house repairing
- Motoring
- Radio listening
- Telephoning
- Watching the movies
- Reading newspapers
- Reading the *Saturday Evening Post*
- Jazz dancing
- Card playing
- Solving cross-word puzzles
- Petting
- Vacationing at beach bungalow
- Going to ball games
- Going to church (?)
- Going to the lodge
- Train and subway riding
- Quick lunch eating

Samoan[1]

- Taro cultivation
- Cooking
- Boat making
- Expert canoeing
- Reef fishing
- Net making
- Weaving eel traps
- Hook making
- Transplanting cocoanuts
- Wood carving
- Cutting copra
- House building
- Road making
- Expert swimming
- Interpretive dancing
- Singing
- Group action with the Aumaga—the men's club
- Intricate courting
- Participation in ceremonials with special language
- Orating
- Inter-island visiting

Park Avenue Banker

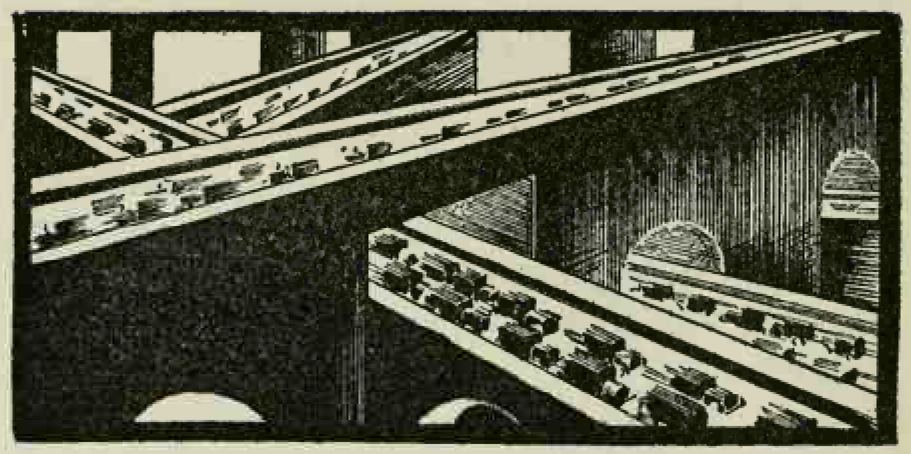
- Attending board meetings
- Dictating
- Speculating in stocks
- Betting and gambling
- Mixing in politics
- Entertaining and week-ending
- Motoring
- Telephoning
- Travelling abroad
- Wintering at Palm Beach (limited time)
- Summering at Bar Harbor (limited time)
- Yachting
- Flying
- Golf playing
- Bridge playing
- Attending banquets
- Attending football games, polo matches and crew races
- Attending opera, theatre, concerts
- Hunting
- Dancing at night clubs
- Reading newspapers and detective stories

The White Plains clerk is a more regimented man, a narrower man, than the Samoan. But if he makes a lucky real estate investment, he always has the chance of moving to Park Avenue, and here the range is wider—though one might still give the Samoan the preference for all-round development. In this event our clerk would pass through two sets of standards in a lifetime, where the Samoan, generation after generation, is limited to one.

---

[1] Compiled from *Coming of Age in Samoa,* Mead.

From all these baffling currents and cross currents, at least three conclusions emerge. Machine civilization as a total culture is less standardized than any given former culture. The life of any modern individual is theoretically open to more variety, but practically may be less varied, than that of an individual in other cultures. The machine is probably the greatest destroyer of standards which the world has ever seen. The temporary standards which have sprung up to fill the gap are all too often ugly and unpleasant. But there is no certainty that they will last. Indeed the only certainty is constant change, so long as technology maintains its present pace.



CHAPTER XVI

LEANING TOWERS

We come now to the three great potential dangers of the machine. The robot, the loss of handicraft skill, social standardization, degeneration in the quality of goods, decreation, accelerating unemployment—constitute major problems of adaptation and readjustment, but all are in flux, their outlines changing from year to year, while certain modifying forces have been noted which may relieve the payment of the uttermost farthing upon these tendered bills.

I see no modifying forces at all in respect to mechanized warfare, to the growing complexity, and hence growing danger, of mechanical specialization—a factor to which I shall give the name technological tenuousness. I see little concrete assurance that the mounting drain upon natural resources, which the flood of goods promotes, is adequately to be compensated for by future discoveries, synthetic or otherwise. On the whole, these three dangers are becoming steadily worse, and are made the more serious by the fact that all are long-term bills, nor has the full value of the instrument been adequately assessed. Mankind has always been loath to bother about bills of an indeterminate sum, collectible in the indeterminate future. That is posterity's little business; and what, it is inquired, has posterity done for us?

It is true that there is an active minority of peace advocates who are worrying about the next great war—sometimes with a fair amount of publicity. It is true that there is a smaller and less active minority of conservationists who are worrying about oil, lumber, minerals and coal—with very little publicity since the passing of the late Mr. Theodore Roosevelt. Neither of these problems has really been driven into the public consciousness; they register as worthy causes deserving of occasional contribution, in the same general class as homes for the relief of indigent widows. For every article in the newspapers picturing the impending smash of the next war, I find a dozen brightly featuring the latest super-dreadnaught and anti-aircraft gun—which ratio indicates in a general way where the public interest truly lies.

The menace of over-specialization, in the sense that we are increasingly dependent for our food, water and stark necessities upon a complicated mechanical process which only a few technicians understand in detail, and which nobody understands in toto, has rarely been touched upon—let alone registering, however passively, on the public consciousness. We turn a handle and water comes. If it does not come, we telephone in some indignation to the plumber, who makes it come. Where it comes from, and by what process, we neither know nor care. We would as readily think of the sun standing still (more readily; for city people seldom see the face of the sun), as of water not flowing—after a due amount of telephoning and tinkering—from faucets. Yet a handful of earnest technicians could, in a few hours' time, bring just such a miracle to pass; and before connections could be reëstablished by amateur engineering—if indeed they could be reëstablished at all—we should run, screaming with thirst, to the scum of the salt water tides. An engineer once told me how something in the order of one hundred key men, operating its veins of water, power, gas, sewage disposal, milk supply, communication, could bring the life of a great city to an end—almost as neatly as though its every crevice had been soaked with poison gas. Even in rural areas with the growing use of electric power, the telephone, gasoline, and imported foodstuffs, the factor of dependence on an unknown technology is very great. When a fuse blows out in my suburban home, we can neither see, cook, nor keep warm. If the current is shut off in the depth of winter, the house becomes uninhabitable within a few hours. The machine has presented us with a central nervous system, protected with no spinal vertebrae, lying almost naked for the cutting. If for one reason or another, the severance is made, we face a terrifying, perhaps a mortal, crisis. All previous cultures have got along with hardly any central nervous system at all; they could be destroyed only village by village, for each was largely self-sustaining.

Two leaning towers will be discussed in this chapter: the tenuousness of the technological structure, and the drain on natural resources. In the next chapter, the third and most serious will be considered—that of mechanized warfare.

Technological tenuousness

The average man makes little more attempt to understand his environment than is necessary to secure subsistence from it. If he lives in a pioneer community, he must know about weather, seasons, crops, domestic animals, wild animals, trees and plants of economic significance, textile making, smithing, carpentering, masonry work, firearms, trails, water courses, pasturage. The day-by-day pressure of his environment tends not only to make him wise in a basic sort of way, but to make him courageous, handy, self-reliant, and independent. Of course if the pressure is too great, it may brutalize and degrade him.

Our White Plains bookkeeper, whom we contrasted with a Samoan some pages back, has no such educative forces in his daily journey from home to office. Survival for him depends upon ability to dodge motor cars;

to read time-tables, warning signals and the labels on packaged foods; upon the use of money and the telephone, the ordering of repair mechanics; and certain details in the general theory of double entry accounting. He may, and he usually does, learn more, but such learning comes under the general heading of a pastime; it seldom has anything to do with the specific conditions of his environment, and has no place in his scheme of survival. He may exercise his muscles a little, having read in the newspaper that such is good for sedentary workers—which gives us occasion to quote the editor of the *New Yorker* in one of his more reflective moods:

> At the Electrical Show we saw how the need for outdoor life had been entirely obviated. For the sun you substitute a lamp; for a horse you ride an electrical animal in the safety of your bathroom; for wind and snow and the buffeting of the elements, you place a strap around your belly and are electrically invigorated. All this is supposed to make a man of you. Unfortunately the Electrical Show came to town at the same time as the Rodeo. We went directly from the one to the other. Puffy salesmen, sitting on electrical horses beneath electric suns, talking sales talk; lean cowboys, riding the horns of flesh-and-blood steers, saying nothing. . . . The contrast duly noted.

The bulk of our clerk's attention is given to the securing of enough money to "maintain his position." Getting money involves a specialized job—one tiny part of the great process of meat packing, textile manufacturing, steel making, department store merchandizing, international banking. To secure his weekly pay check, he needs to understand only this fraction, and check his invoices, or add up his columns, with reasonable accuracy. As a result he tends to lack that self-reliance and handiness, that certain basic wisdom, which are the normal heritage of the pioneer, of the resident in the self-sustaining village, of nature peoples generally. The modern slum dweller and industrial worker are in similar predicament. They require more courage than the clerk, but perhaps even less knowledge of the forces which control their environment.

The case is not necessarily serious, however, so long as machine civilization continues to function. These people have no immediate need for more knowledge. As for the degeneration of character, the bright face of danger persists on any city street; in most factories and outside construction jobs, as the accident figures show; while the sense of power which comes from driving a motor car has done much to stiffen modern backbones. Also we are always pursuing a witch called Success, who if she does nothing else at least stimulates the adrenalin. I am not so much concerned about the character of a shipping clerk with a line of wise cracks and a Chevrolet, as I am about his ignorance of the environment which furnishes him food and shelter. Just what is he going to do if the machine stops? How does he know that it will not stop? Whom shall he find to repair it if it does stop in any basic sort of way? The situation is not so serious as that depicted by

Mr. Forster and set forth in Chapter I. Neither is it entirely new, for in earlier civilizations slaves rather than machines acted as a cushion between citizens and the means of subsistence—but it is serious enough. Our connection with the realities of our environment is far more tenuous than was ever the case in Imperial Rome.

Technology is developing at an incredible pace. In a single week I have listed as many as fourteen important new inventions and discoveries. Private interests are continually capitalizing these inventions and introducing them into the industrial structure, often with the formula kept secret. Public safety is usually a minor consideration in such introductions. (If you doubt this general statement, ask the Gas Association to give you a list of the deadly gas stoves and heaters which they are trying to eliminate from the market.) Safety is the business of public inspectors, whose fields are limited; and of whom many, alas, have their price.

We draw up to a filling station and order gasoline which according to a bright sign promises more miles to the gallon. Some time later we hear of workers dying in Bayonne, New Jersey, from the effects of manufacturing this selfsame gas. We admire the figures on our watch which gleam at night, only to pick up the paper and learn that the inventor of radium paint has been killed by the effects of his own discovery. Who is watching all these new products that are so gaily advertised; and all these interlocked pipes, wires, rails, conduits, tunnels, services, which are about us in ever greater complexity, and upon which our life depends? Nobody is watching them except in the most haphazard way. Adam Smith's doctrine of the "invisible hand" leaves such observation largely to private enterprise, and private enterprise has no desire to inflate pay rolls with more than the minimum number of inspectors, and no desire to coöperate with brother interests in setting up a clearing house of knowledge. Such undertakings would cost money, and what is infinitely worse, give trade secrets into alien hands. It is nobody's business to know, and nobody does know. Certain services, say municipal fire departments, are well inspected and well protected; for the rest we can only hope for the best. That this hope is sometimes over-optimistic a few recent headlines indicate.

A mile of London streets ripped open by gas explosion—paving thrown into the air like confetti.
Gas fells thirteen Bronx tenants.
Sixteen killed, seven injured in factory blast that fires homes.
Man rescues four in ammonia blast.
One burned to death, twenty-five overcome in gas explosion.
Fever produced artificially by radio.
Los Angeles dam breaks, four hundred drowned.
Seventeen killed, one hundred and one injured in New York subway disaster.
Ohio coal mine fire now burning for forty-four years. Cannot be extinguished, 700,000,000 tons of coal burned to date. Eating under whole countryside. Farm lands collapsing.
At sixty miles per hour, an automobile will travel just

forty-five feet before the human nervous system can signal hand and foot to start putting on the brakes. At forty miles the reaction distance is thirty feet.

A chemical company in Hamburg, Germany, allows phosgene gas to escape from stacks. Hanging like a blanket over city. Eleven persons dead from effects.

Learn aviation at home in easy lessons (perhaps the worst exhibit on the list).

These are but minor symptoms of the standing threat of technological tenuousness—tiny barometers which nevertheless register a constant pressure.

Below the streets of New York City you will find:

1. Vaults under sidewalks, which the abutting building may rent for storage, delivery service, or even for work rooms.
2. Electric light and power cables.
3. Telephone cables—up to 2400 wires on a single cable. (To enlarge the telephone service of New York City since 1920 has cost $500,000,000. To cut the Panama Canal cost $300,000,000.)
4. Water mains—from six feet to six inches in diameter. If the former burst, they "cause more havoc than dynamite."
5. Gas mains—spreading wholesale death if punctured.
6. Steam mains—carrying heat from central plants to office buildings.
7. Mail tubes.
8. Telegraph cables.
9. Sewers—some of them made of brick and big enough to drive a truck through.
10. Subways—140 miles of them in New York. In some places there are four tubes, one below the other. They

> carry the equivalent of the entire population of the United States every two weeks. Whole system is now being doubled at cost of $700,000,000. Other pipes and cables have to be lifted to street, a most delicate procedure. Existing lines must be propped up, skyscrapers underpinned. The Columbus monument, weighing 724 tons, has to be trussed up for the second time. Blasting must be carried on close to four-foot water mains.

In addition to these underground phenomena, we find various services upon the surface of equally important if not so mysterious nature. Bridges and causeways which admit traffic, particularly foodstuffs, to the city, come under this head. So do docking facilities, railroad switch yards and their signals, surface and elevated transit lines, the organization of milk and ice supply, fire-fighting apparatus, street traffic—particularly delivery by truck, and street traffic control by signal lights and officers; health and hospital services for the control of infectious diseases, garbage collection—a very tender nerve; burial services; elevator services—without which hardly more than ten per cent of normal business could be carried on; street cleaning and snow disposal, building inspection for innumerable safety provisions including ventilation, fire hazard, and proper construction materials, smoke and dust abatement services, factory inspection—and presently the provisioning of landing fields and the control of communication by air.

There is hardly an item on either the subterranean or the surface list which is not cardinal to the continued existence of our clerk and all his fellow citizens. If one prime nerve is cut for any length of time, his environment will start rapidly to disintegrate, leaving him as helpless as a rabbit in a trap. Furthermore, so interlocked is the whole system that the failing of one nerve is almost sure to result in the rupture of others. If electric power goes, the whole city is plunged in darkness, every motor stops, and subways, surface cars, elevated trains, water pumps, fire signals, hospitals, elevators, refrigeration, incoming food and milk supplies immediately face collapse.

Who understands the technological functioning of these services, and their interlocking relationships? Where are the men to replace the handful of technicians who might sever or irreparably wreck their own service, hardly knowing the extent of the ruin it might cause? When no one man in the Telephone Company understands the latest dial system—it takes about five of them to master it—where is the central intelligence to nurse a great city through a nervous breakdown? The answer is, nowhere. What is worse, the problems involved are far too complicated to be grasped by any one mind, or by any small group. It would take a very considerable intelligence service, functioning continuously, with a large clerical force and elaborate filing system, to provide any sort of insurance against a metropolitan calamity. I am not sure that adequate insurance does not demand special educational courses for the entire population in the broad outlines of the problem, together with instruction in specific tasks in case of crisis—a sort of general civic mobilization. I do not necessarily recommend such a program; but am only speculating as to what adequate insurance under machine technology entails. My recommendations would run to more spacious, less populous cities, without bowels riven by ten separate circulatory channels.

You may object that no great disaster has yet overtaken a mechanical metropolis. With the exception of Tokio, this is true. We must remember, however, that the whole development is very recent, permitting no adequate historical testing-time as yet. Day by day the complexity, and hence the potential danger, accelerates; materials and structures ceaselessly and silently deteriorate. One may look for some very ugly happenings in the next ten years.

We have already had reasonably specific experience with a kindred urban problem—that of the one-industry town. When the mill owners of New Bedford recently declared a wage reduction, and their operatives went on strike, a most extraordinary thing happened. Almost to a man, the city supported the strikers. Newspapers, shopkeepers, landlords, bankers, insurance men—everybody lined up behind them. Because their hearts were pure? Rubbish. Because New Bedford depends exclusively on its cotton mills, and with the workers on the streets, there was no buying-power left in the town. Business came suddenly to a standstill. The same thing happened, in a less complete way, when Ford changed from Model T to Model A, throwing 60,000 men out of work and clogging the trade and production of Detroit. Lawrence, Haverhill, Gary, Passaic—and many more that could be mentioned both here and abroad—are one-industry towns. If any breakdown occurs in that industry, the whole city faces depression, misery, even starvation.

The factor of tenuousness applies not only to cities.

> If the 200,000 trained enginemen were blotted out of existence tomorrow, the social and industrial life of the nation would be paralyzed. Mines, factories and public utilities would cease production. Food supplies would accumulate remote from the great markets. Babies would die while men and women fought for bread and meat. It would take not months, but years to train the men necessary to restore the constant reliable flow of commerce.

If steamships filled with food ceased landing in English harbours, Mr. Philip Gibbs gives the population three months to starve to death. As it is a million men, women and children in the mining districts are today on the brink of starvation because internal combustion engines, hydraulic turbines, and a declining foreign trade have reduced the demand for British coal. Over a quarter of a million miners will never enter the pits again. California is almost exclusively dependent upon oil for her power. If the oil supply were cut off, she would have the utmost difficulty in shifting to a coal basis.

Machinery without lubrication is unthinkable. Modern industry is built upon petroleum lubricants. According to Mr. G. W. Stocking there is no quantitative substitute for mineral lubricating oils. A sufficient supply of vegetable oils would require such an acreage as to cause serious inroads on the food supply. Competent engineers have given American petroleum from six to twelve more years before it is exhausted. Stretch this period with imported supplies or whatever you please to twenty years. What are our machines going to do when it runs out? Nor am I particularly interested in a cheery "something will be found."

> Wherever mechanical industry has taken decisive effect . . . the community lives from hand to mouth in such a way that its livelihood depends on the effectual working of its industrial system from day to day. . . . By themselves alone, the technicians can, in a few weeks, effectually incapacitate the country's productive industry. . . . No one who will dispassionately consider the technical character of this industrial system will fail to recognize that fact.

Mr. Veblen estimates the number of men necessary to do this at "no more than a minute fraction of one per cent of the population."

Among what might be termed the "paralytic trades," we note the following:

Locomotive engineers
Locomotive firemen
Telephone girls
Telegraph employees
Post office employees
Coal mine pump men
Oil well operatives
Central power plant operatives
Linemen
Switchmen
Trackmen
Motor truckmen
Milkmen
Water, gas, sewage employees
Railroad signalmen
Firemen
Policemen
Rapid transit workers

Less drastic but still serious

Steamship crews
Doctors and nurses
Traffic officers
Ice men
Plumbers and electricians
Printers
Bank clerks
Freight handlers

England had a taste of tenuousness in the General Strike of 1926. Fortunately for the government, the basic nerves were never really cut. Had they been —say the water supply of London—the government would have been forced to its knees in a few hours. Some day an embittered labour movement, or even a small key labour group, may really cut a nerve. Some day a struggle between two business groups may cut a nerve. Some day an earthquake may cut a lot of them —a quake which would not do appreciable damage in a village. On that day, our White Plains clerk will discover that faucets do not manufacture water, nor delicatessen stores food.

The menace of technological tenuousness takes two distinct forms. First, the possibility of dramatic action by man or nature. Second, and I think even more serious, the sheer piling up of technical services one upon the other, which nobody understands, or tries to understand in any synthetic way, and which may result in spontaneous collapse—without help from man or nature. The standardization and simplification movement is facing certain minor aspects of this problem, but I do not find it actively diminishing traffic congestion on Fifth Avenue.

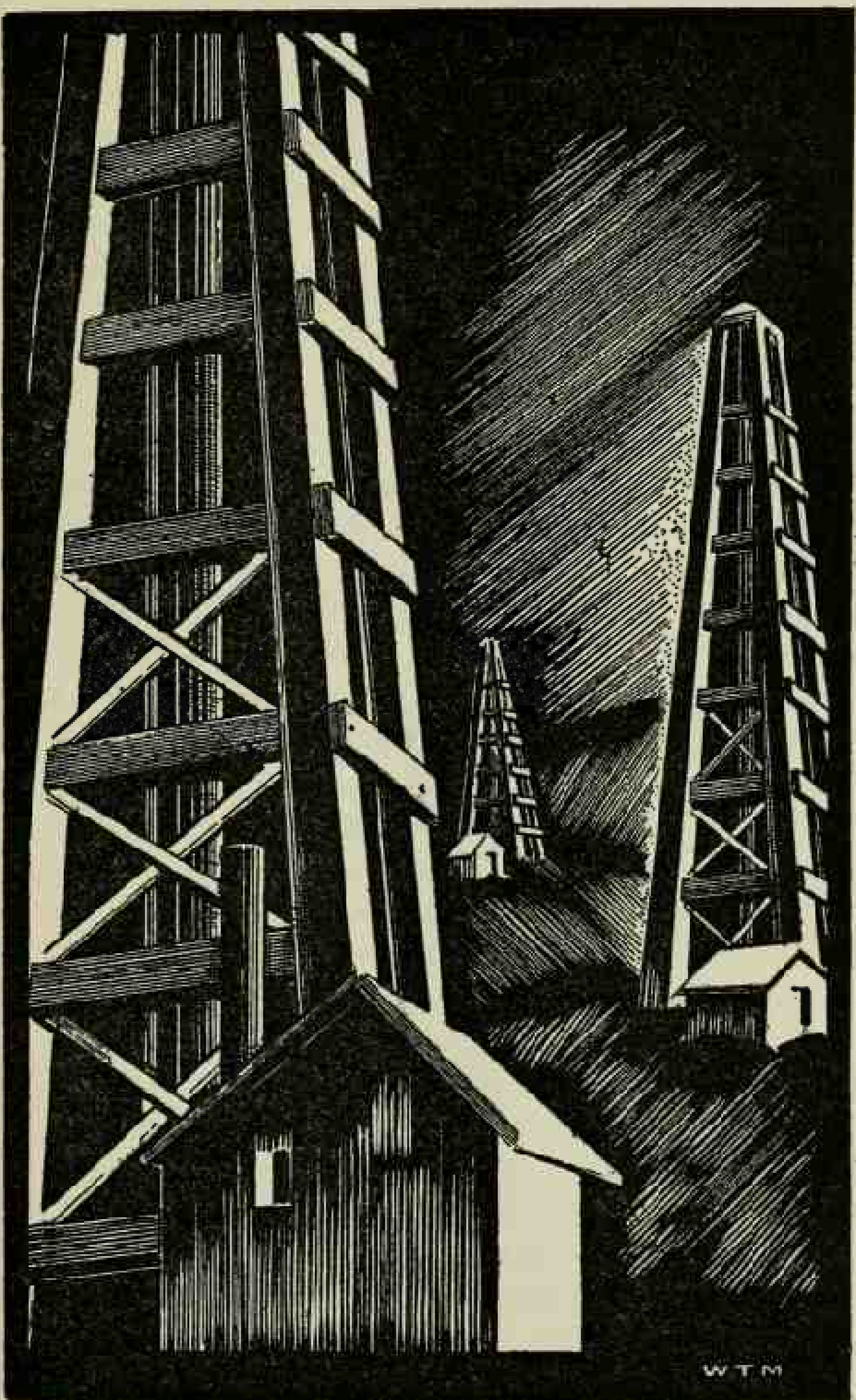
The drain on natural resources

You may remember the lawn of the suburban family piled high with its annual quota of coal, iron ore, lumber and lead. The machine is swallowing natural resources at a fantastic, an inconceivable, rate. It has used up more oil in the last ten years than all the oil consumed since the beds were laid down, some millions of years ago. It has used up more minerals since 1900 than in all previous history.

A good half of the volume is wasted in exploitation, another large fraction falls by the wayside in fabrication, leaving a net product for final consumption, of which a high percentage, as we have seen in earlier chapters, is worthless junk. In other words, an equal standard of living could probably be derived by prudent and thrifty exploitation of not more than one quarter of the present tonnage shovelled and pumped from the crust of the earth. To the time of Watt, mankind lived primarily on the interest derived from its store of natural resources. Increasingly since 1800, and for the past generation with blind fury, it has been tearing into its capital—on a scale that precludes replacement. All the Western nations have demonstrated their fitness to be classed as prodigal sons, but the gayest, most lighthearted, most charmingly rattle-brained of the whole family is certainly the United States of America. This stripling lights his cigarette with a million dollars' worth of coal, and throws the match to kindle a million dollar forest fire. "Our habit of stepping on the gas," says George Otis Smith, "has brought the mineral industry close to the danger line." And he adds that a nation's wealth may also be measured by its power to last. The rate at which a spendthrift divorces himself of his capital has ever been a poor measure for the value of an estate. We are already beginning to import raw materials in increasing amounts, and before we know it, our sometime economic independence will have run its course; we shall be drawn willy-nilly into world economy, and the delightful pastime of looking down upon the economy of our neighbours because of the iron, coal and oil under our feet, will come to a conclusion.

A necessary distinction must be drawn between resources which will grow again, and those which, once used, are gone forever. Lumber is an example of the one, and copper of the other. A further distinction lies between wasting assets whose supply is virtually unlimited—like stone or clay, and those whose life will terminate within a calculable period—like oil. Stone need not concern us; lumber may be brought back by a great and costly system of afforestation, in which timber culture is substituted for the present practice which has been called timber mining; but oil will end, and take with it the food of half a billion horses.

The story of the prodigals amid the assets of their mother earth has been told in detail elsewhere by com-


W T M

petent geologists and engineers. Here we can but recapitulate their findings; first in respect to wasting assets, and then for those which can be made to grow again—when society assumes the receivership of the properties ruined by private enterprise.

Oil

The United States Petroleum Conservation Board gave us (in 1927) six more years of oil, if no new fields were discovered, and the consumption rate did not drastically change. Since then, a few new fields have been found, but the number of such fields is limited. Other estimates have run as high as fifteen or twenty years. A crisis will probably come in the next decade. Reserves in other countries are large, but when subjected to the full pressure of 30 million foot-throttles (which we shall have in a year or two), it is dubious if they can last a generation. Meanwhile for every barrel of oil reclaimed, nine barrels are wasted, according to current methods of exploitation.

Natural gas

This marvellous fuel is better than sixty per cent exhausted, chiefly in the form of waste. Every year 100 billion cubic feet of it is allowed to blow off into the air, while in the Cushing Oil Field of Oklahoma alone the daily waste has been set at 300 million cubic feet. Natural gas can hardly last out the next decade in a volume that has appreciable economic effect.

Coal

The United States has mined only about two per cent of its total supply to date, but there is coal and coal. Some of it is applicable to coking and destructive distillation, and some is not; some of it is very difficult, if not impossible, to mine. Of low volatile smokeless varieties we have only limited reserves; while our high volatile gas coals are being rapidly exhausted. More than a third of the high-grade beds have already disappeared. Many English mines are getting so deep that the cost of recovery is approaching the upper limit. There is plenty of coal in the world, but it grows harder and harder to get at, particularly in the grades most needed. Meanwhile so great is the margin of waste that only about four per cent of the thermal energy contained in a ton underground is turned into usable power by the average steam engine.

Iron

The high-grade ores in the United States have the "possibility of being exhausted at a comparatively early date," according to George Otis Smith.

Copper

At the present rate of exploitation we shall see the "practical end of copper mining in the United States in the present generation."

Soils

Soil can be brought back to life by refertilization, provided there is any soil to bring. The difficulty in the United States is that the soils are tumbling into the rivers where all the King's horses and all the King's men can do nothing about it. J. Russell Smith tells us that we "are going to economic Hades faster than any country on earth" by virtue of soil exhaustion. The axe, the plow and the cultivator are the devils in the drama. When the roots come out of the upland wood lot, the soil is weakened, the plow combs it thinner and the rain finishes the job. It takes just fifteen years for a North Carolina field to be born and die. Corn, cotton and tobacco are the worst crops because they compound the evil of the plow with that of the cultivator. Smith pleads for crops which will hold the soil, like alfalfa. One fears that his is still a voice crying in the wilderness.

Lumber

We are now cutting our timber four times as fast as it is growing. The end promises to come within thirty years. The printing press is rapidly overtaking the band saw as a devourer of lumber. It is technically possible to meet our needs without drain on forest capital, but not under the enterprising methods of the "invisible hand."

Fisheries

The combination of stream pollution and highly efficient methods of mechanical extermination is threatening, according to President Hoover, our fisheries with extinction. (We note with pleasure, however, a recent device by which a pair of electrodes placed in a mill race shocks fish away from the blades of the turbine.)

The inventory could be extended, but the above is sufficient to illustrate the airy prodigality of our present methods in the exploitation of natural resources.

Waste is an ugly thing in itself. But in the case of a deposit good for a thousand years or more, it means hardly more than exasperation at the stupidity of the procedure. In the case of oil, which may not last at negotiable prices to 1940, exasperation, to an imaginative mind, can only give place to plain horror. Those who have the oil supply in charge rear a vast technology on petroleum, make it indeed the outstanding exhibit of the Power Age, and then ruthlessly kick it out from under us. Something will be found, it is declared—shale, bitumin sands, alcohol from potatoes, gasoline from coal, sea water, something—"the miracles of science are in their infancy." I know all about the miracles of science—and some of its majestic failures—and, I ask you, gentlemen, what precisely, and at what cost, will be found?

CHAPTER XVII

THE TWO-HOUR WAR

ON the 13th of August, 1928, the "Northern Power" opened its attack upon London. Seventy-five airplanes, each carrying five hundred pounds of "bombs," swooped down upon the city from the northeast. They were met by an equal number of defence planes, by batteries of anti-aircraft guns, by an extensive balloon system—by every known device for defence against an air attack. But within less than thirty minutes after crossing the coast line, the defence planes had been eluded, the attack had centred directly over London, "bombs" had been dropped on predetermined targets, the Air Ministry Building, power-houses, water works, indeed all government and strategic buildings were in ruins—and the attacking force was wheeling back into the north *without a casualty*.

Every specified objective was bombed. Fifty thousand pounds of theoretical explosives were dropped through 16,000 feet, with the accuracy of gun fire. Had these twenty-two tons of bombs been filled with diphenyl chloroarsine, half of the population of London would have been wiped out, 3,750,000 men, women and children, according to the calculations of the judges. Fifty tons of gas would have destroyed every living thing in the London area—an amount readily negotiable by a force of two hundred planes. The attacking planes, furthermore, were manned mostly by civilians in order that the defence might have the maximum advantage.

This whole drama, needless to say, was mimic warfare, but it was carried out with meticulous detail, and the results I have cited were the sober conclusions of the army judges. All known methods of defence were helpless before seventy-five amateur pilots. Not a single attacking plane was downed. Imagine what might be done with five hundred planes manned by experienced army pilots—a force which every one of the leading nations can readily mobilize.

France is now in a position to bring four thousand planes into action at the call of the radio. She is prepared to drop one hundred and twenty tons of bombs in a single raid. This measures progress since the Great War, when the maximum tonnage of bombs dropped in any month was twelve. Yet five of these antediluvian planes broke up the whole Turkish army on its march to Palestine. Germany is experimenting with silent and invisible aircraft—muffled exhausts and camouflaged bodies. The British Ripon plane is capable of a speed of one hundred and fifty miles an hour, can ascend almost vertically, and is fitted with racks for assorted bombs. Recently one of these monsters dropped a torpedo weighing a ton in the Humber. A far smaller bomb carried by a tiny airplane, sent the great battleship *Ostfriedland* to the bottom in a recent test. Mr. J. M. Kenworthy, M.P., tells us of a 4300-pound bomb, capable of displacing one thousand cubic yards of sand; which, if dropped in Piccadilly, would cancel the whole street. He also predicts shortly a three-hundred-mile-per-hour plane, as well as automatic planes, steered by wireless from the ground, with bombs released by wireless.

There are at least two varieties of poison gas against which no mask is any protection. Cacodyl isocyanide is in the possession of all the great nations, a gas so frightful that, preliminary to hostilities, military men admit to reporters that they do not see how they can bring themselves to use it. There are also irritating gases which cause the sufferer to tear off his mask, and thus take a good full breath of the poison gas which has previously been laid. Government purchasing agents can take their choice of bombs filled with deadly plague bacilli, or with anthrax for the extermination of milk cows and horses. Eight scourges are chemically available for germ bombs: yellow fever, dysentery, diphtheria, malaria, typhus, plague, cholera and typhoid fever. "Cultures can be prepared readily and in great volume; chemical factories can get into uniform in less time than it takes to write"—according to M. Albert Lapoule. Meanwhile the "radium atomite" just discovered, is a more powerful explosive than T.N.T.

. . . War is declared. Nay, war is only threatened —for he who speaks first, speaks last. In Bremen, or Calais, a thousand men climb into the cockpits of a thousand aircraft, and under each is slung a bomb which the pressure of the finger may release, together with instructions as to where, precisely, and at what altitude, that pressure is to be applied. A starting signal, an hour or two of flight—a little veering, dropping and dodging as the defence planes rise—a casualty or two as the radium atomite of anti-aircraft guns tries vainly to fill a space one hundred miles square and four miles deep—one muffled roar after another as the bombs are dropped per schedule—and so, to all intents and purposes, the civilization founded by William the Conqueror, which gave Bacon, Newton and Watt to the world, comes, in something like half an hour, to a close. Finished and done. London, Liverpool, Manchester, Lancashire, Bristol, Birmingham, Leeds—each has had its appointed place on the code of instructions, and each now duly makes its exit from the list of habitable places on the planet. Not even a rat, not even an ant, not even a roach, can survive the entire and thorough lack of habitability. Every power nerve has been cut with explosives; every living thing has ceased to breathe by virtue of diphenyl chloroarsine. Even the author of *Man and Superman,* who had so often and so successfully defied whatever gods may be, lies prone at last upon a London sidewalk, a ghastly smile on his fine white face, and a hand flung out upon which a burning beam has fallen. . . .

"No convention, guarantee or disarmament safeguard can be relied upon to stop a powerful nation from using the most effective weapon it has." The most effective weapon, and all powerful nations have it in great numbers, is a machine capable of moving at great speed in a mixture of oxygen and nitrogen. In effect it has reduced all other weapons—battleships, artillery, fortresses, machine guns, tanks—to so much scrap iron. The only thing it cannot be sure of harming is a submarine—with a hundred feet of ocean over it. This latter mechanism, if it stays under far enough and long enough, can still do some damage to enemy shipping, but its methods to my mind are over-cautious and over-costly.

A good submarine costs about $5,000,000; it requires a crew of thirty men, its speed does not exceed twenty miles an hour submerged, and it is not a very straight shooter at the best. A good airplane may be had for $5,000, its crew is one, it can travel at two hundred miles an hour, and it can drop a bomb, as we have seen, with remarkable fidelity to its intention. If I were Secretary of War, without too heavy an investment in the capital stocks of steel companies, I should prefer to save my countrymen taxes and my enemy any lack of annoyance, by destroying his shipping from the air, rather than from the depths. As for the submarine's function against enemy battleships, no battleship will dare to leave its harbour; nor should I, for one, care to take up more than the most temporary residence upon it while in its harbour, after the declaration of hostilities. Submarines of great size and cost might conceivably be of some use in shelling coast cities with well chosen varieties of poison gas for the few minutes it would take the air force from those cities to get their bombs suspended above them. Then they must choose whether they will go down temporarily or forever.

In short, it hardly pays to discuss any mechanism of warfare except the airplane. It has the advantage both of being infinitely more deadly than any other weapon, all factors considered, and of being cheap. It can be built in a few weeks, and its cost, relatively speaking, is a trifle. Its outstanding primacy comes, as I see it, from the fact that it can operate in three dimensions, where all other weapons—both present and past—are constrained to one or two. A submarine can operate in three dimensions, but only by slow and cumbersome wallows, nor can it find very much of a belligerent nature to operate upon save sharks. A projectile travels in a straight line with a curve at the end, and so is essentially a one dimensional affair. The new gas bullets are said to be capable of turning corners, which gives them a temperamental two dimensions. A battery, or broadside, can cover a curving plane. Cavalry and infantry can work in two dimensions, and so can a tank, but when a defile or a pass is to be defended, the whole manœuvre slows down to one.

Against all attacks developed on the rough plane of the earth's surface, defences can be set up. The space through which the offence can move is more or less rigidly circumscribed. Knowing these limits, the defence can act accordingly, and has time to act accordingly. The *Merrimac* brought forth the *Monitor;* heavier guns brought forth heavier armour plate. For every offence there is a defence—usually a good one.

But for a three-dimensional offence there is no defence—or only the sorriest kind of a defence, as the attack on London showed. (Some genius has suggested that piano wire be suspended from balloons to trap the air offensive. He should receive a prize from a comic weekly.) The possible points of attack are suddenly cubed. The only way to keep airplanes out of a metropolitan area is to have enough anti-aircraft guns to fill four hundred cubic miles practically solid with steel splinters and T.N.T. This would involve, first, a fantastic number of guns, and second, the grave discomfort, if not the positive slaughter, of the metropolitan population—who could not move on the streets without umbrellas of heavy steel. Defence by home airplanes is almost equally futile. There is too much space through which the attacker can slip. Tag is a good game on the ground, but it loses all charm in the air.

Military strategy, however, has an easy answer to the problem of the three-dimensional attack—an answer which has been the current coin of successful generals for thousands of years, of which, indeed, every chess player is aware. The best defence is an offence. And so the instant the thousand planes leave Hamburg for the cities of England, fifteen hundred planes leave London for the cities of Germany. Their ways may cross, but owing to the slipperiness of space and the haste of each squadron to reach its appointed powerhouse or Treasury building on schedule, the casualties will be few, and the end of two civilizations, rather than one, not long delayed. As such things go, another ten minutes at the outside.

There is one good thing certainly to be said about the next war: it will not keep us long on edge. We shall not have to worry about finding the money for Liberty Bonds, whether George is going to get his commission, Fred has been transferred to the front line, or Alice is really determined to have her war baby; we shall not have to search our hearts to uproot any vestiges of sympathy or sometime affection for alien enemies. The whole business will be over in a couple of hours. With lungs full of diphenyl chloroarsine, we shall not need to worry about anything ever again.

The United States and Russia, with their great areas, cannot be obliterated with the same praiseworthy dispatch as can the other great powers. (England and Japan on their crowded islands obviously will be subject to the most efficient extinction.) But a swarm of planes setting out from Toronto could well finish Buffalo, Rochester, Boston, New York, Philadelphia, Baltimore, Washington, Pittsburgh, Cleveland, Detroit and Chicago in a reasonably short time. Particularly complete would be the termination of New York. With her bridges and tunnels bombed, with her many tall buildings crashing like glorified tenpins, with her super-congestion, citizens would hardly have time to seize their check books before being summoned to the waiting rooms of the recording angel.

I see no possible way out. The technological design of the airplane—not the airplane of tomorrow, if you please, but the airplane of today—provides for precisely the results I have been chronicling. This is the sort of thing which airplanes, with bombs swung below them, pilot controlled or automatic, are perfectly equipped to do. Nor is there any known way to stop them. These bristling pictures of anti-aircraft guns in the Sunday Supplements, together with General Fossil's account of their range and accuracy, are an insult to the intelligence. These super-dreadnaughts throwing up great walls of spume, beautiful as they are as pieces of engineering, are an even worse insult. These gas masks for every man, woman and child are the worst of all.

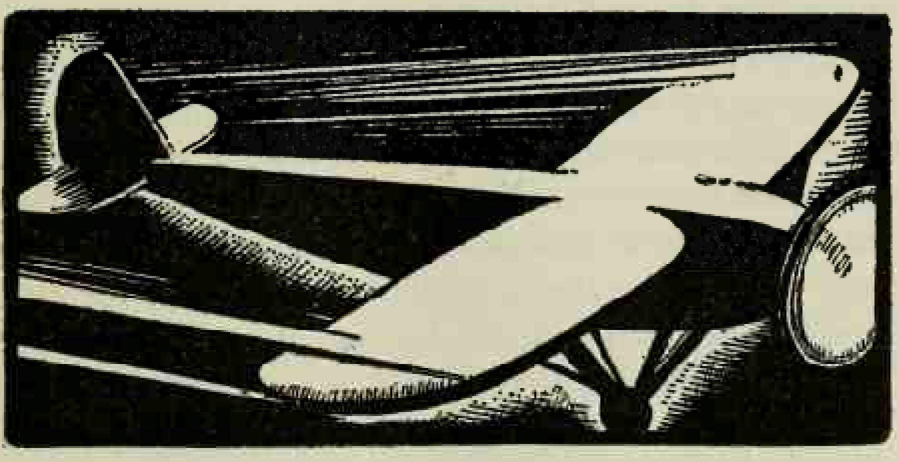
It is contrary perhaps to the code of the sportsman, but every now and then I know when I am beaten. I am willing to fight against the domination of as many peace-time mechanisms as you please, with a hazy but still enduring confidence in victory. But against a three-dimensional war machine, I have no confidence of anything save that the unique association of electrons which comprises myself is about to form new and interesting chemical combinations. This, I confess, intrigues my imagination, but no more than if you pointed a revolver at my head and gave me three seconds in which to die.

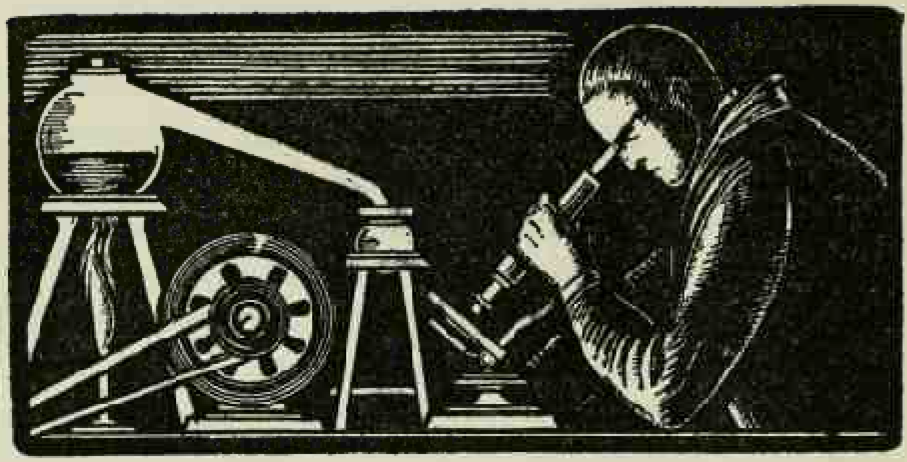
My notes show a whole galaxy of war machines which I have not even described—terrific affairs, but all operating in one and two dimensions. Yet for all this documentary remissness, I think that I have said enough. Perhaps I have said too much. There may be a practicable defence against the airplane among the secrets of the several Colleges of War, waiting for opportunity to prove its worth. If so, it is a secret that has been remarkably well kept.

One final qualification there must be. One can readily visualize the liquidation of two great nations in the next war, possibly of two coalitions; but hardly the whole of Western civilization, and certainly not the whole world. .It takes a great deal of poison gas and many airplanes to kill two billion people. My guess would be that nothing will stop the defensive-offensive in the air of the two belligerents, and the neat balancing off, in a few hours' time, of all their temporal affairs.

The persons capable of imagining the holocaust in advance are so few, and of such slight influence—particularly in war and navy departments—that the world cannot realize what it now faces until it has faced it in a *fait accompli.* Then, and not until then, realization will come—possibly, as the extras bring one incredible horror after another, it will come very fast. Perhaps within a few days, after the two belligerents have liquidated their accounts, the neutral world will be in a sufficient state of shock to see that this sort of thing must stop. Forever.

The surviving West, together with the East, will then ban the machine from war—which means, of course, the banishment of war. . . . Or so the conclusion hangs, neatly balanced between the hope and the belief, within my mind.





CHAPTER XVIII

THE BALANCE SHEET

We have come to the end of the trail—such as it was—and not without scratches and abrasions. It is now the turn of the philosophers to laugh at us with all this wild scrambling for our pains. Let them laugh. At least we have collected figures and facts, which sometimes do, and sometimes do not, justify their more intuitive conclusions. There are far more prickly difficulties in the way of taming the machine than the optimists have allowed for. There is less standardization, less blind machine-tending than the gloomy ones would have us suppose, though their shaking of heads as to war seems to be amply justified. Nor am I, for one, greatly impressed with the doctrine of man as the slave of mechanization. Rather engines have been enslaved by man, but the system of discipline has been so poor that riots, uprisings, stampedes have constantly occurred, and more may be expected at any moment.

The time has come to put down, one after another, the specific effects which we have noted in our journey—together with a few which have not been noted but are sufficiently obvious—in an attempt to see where the balance lies. The items on this far from mathematical balance sheet will be grouped under three heads: effects manifestly good; effects manifestly evil; effects containing elements of both. It is, of course, a personal appraisal with which you have every liberty to differ. Indirect as well as direct results are included, and potential effects are also given a place. I have tried to arrange the items on each list roughly in the order of their importance, while keeping kindred matters together. The statements will be bare, with no attempt to prove them. Evidence may be found in the chapters which have gone before.

Effects manifestly good

The life-span of modern peoples has grown longer. The average expectancy of life has increased a third in the past two generations due to medical and mechanical controls.

Higher living standards have been secured for a larger percentage of the total population than has ever before obtained. (But Peru, under the Incas, and various nature peoples located in regions of abundant food supply have, with fewer material things, probably been more comfortable.)

The shrinkage of space brought about by machinery is demonstrating more forcibly every day the essential social and economic unity of the world. It is inviting an era of international coöperation. While the logic is inevitable, the acceptance thereof is still reasonably remote.

Class distinctions founded upon land ownership and patents of nobility are gradually disintegrating, while a levelling process in respect to prestige is going on between all classes.

Hours of labour have decreased in recent years. We still work harder and longer than have many former societies with a hundred holidays or so a year, but if the machine were permitted to function as a true labour-saving device, we could undoubtedly do better in this respect than was ever done before. The curse of Adam has not been appreciably lifted, but it could be.

Superstition is declining. The wayfaring man is somewhat readier to ask: "What makes this thing act the way it does?" rather than falling on his face before unknowable mysteries. He has a more causative philosophy than previous wayfaring men —which does not prevent him from manifesting quite superior idiocy in other directions.

Certain machines, particularly the automobile, have tended to expand the ego, promote self-confidence and a sense of power in persons and classes who otherwise might go timidly to their graves. This virtue has its drawbacks, but on the whole, biologically and racially, it seems to register a gain.

The mechanical operation of industry is beginning to introduce a "philosophy of fatigue," whereby elaborate tests determine just how long a given individual can work without fatigue poisons damaging his output. No other culture ever dreamed of such controls; controls which obviously make for better physical and mental health. The process is still in its infancy.

Even as pure science brought forth applied science, the necessities of industry have stimulated a great variety of researches into the fundamentals of physics and chemistry. The one has interacted with, and helped to develop, the other.

Cruelty as a social phenomenon has undoubtedly decreased in the last century—of which the strong movement for the abolition of capital punishment is but one indication in many. Coincidentally, the radius of social sympathy has increased. Who used to weep for famine sufferers in China? Now the cable and the camera bid us weep in short order—and we do, to the tune of millions a year. A citizen of Rome, one suspects, would have regarded the Red Cross as so much moonshine.

Effects manifestly evil

The menace of mechanized warfare grows daily more ominous—particularly in respect to the airplane capable of the three-dimensional attack.

The tenuousness of connection and balance in the interlocked industrial structure also grows. Any crisis—such as a strike of key technicians, a struggle between rival industrial groups, or an act of God may seriously, perhaps horribly, upset the whole social equilibrium. There is also an alarming shrinkage in the average man's understanding of the technology which shelters, clothes and feeds him. Technical achievement and public ignorance of its implications are tending to move with equal velocity in opposite directions.

Natural resources are being exploited at a rate as alarming as it is wasteful.

The factor of monotony and wearisome repetition in mechanical work is an ever-present evil, particularly if the worker is temperamentally ill-adjusted to the process.

Specialized tasks are sundering the ancient trinity of work, play and art, and thus tending to upset an admirable, and perhaps biologically necessary, human equation. Meanwhile commercialized and mechanized recreation with its second-hand rather than first-hand participation, is tending further to upset the equation.

Specialization has enormously promoted the importance of money, and made it the *sine qua non* of modern life. This leads to a serious confusion of values, in that the symbol displaces the underlying reality.

Workmen are displaced by machinery faster than they can be absorbed in other occupations without serious social cost. Furthermore, the phenomenon of accelerating unemployment, if not already here, may conceivably arrive at any moment.

The existence of more machines than purchasing power to absorb their output has led to the foolish and expensive antics of high pressure salesmanship, and the growing danger of competitive imperialism.

Machinery has created a new ruling class based on profits—largely manufacturing profits—which is no improvement upon the earlier suzerainty based on land, except that its personnel is subject to a greater rate of turnover. Certain of its parasitic dependents are so immersed in the flood of goods that they cancel out as any asset to the race at all. They can be viewed at reasonably close range and in full regalia, in the first cabins of

Atlantic liners or in the pages of *Gentlemen Prefer Blondes.* The idle rich are not a new phenomenon, but the scale on which they now operate is unparalleled.

It is claimed that the ratio of mental diseases to the whole population is increasing. I find no satisfactory proof of this claim, but if it is true, it registers a fundamental count against the strains and stresses of machine civilization.

The increased speed and use of the mechanical process has made for a greater accident rate in the United States since 1920. This may, however, be only a temporary phenomenon while adjustment to mass production is being made.

At the present time industry is clearly overvalued at the expense of agriculture. Too much attention is being given to the former and not enough to the latter. In the United States agriculture is in a state of chronic depression in some of its departments all the time, and in all its departments some of the time.

Mechanization has led to cities so congested that it gives little pleasure either to live in them, or to contemplate what will happen if the pressure becomes much greater. It is estimated that traffic congestion now costs the city of New York a cool half billion a year. This again is not a strictly new phenomenon, but its scale is unprecedented.

Machines have engendered a volume and variety of noise hitherto unknown, and which in the opinion of certain medical authorities is damaging both the ears and the whole nervous system of those subject to it.

Dust and smoke constitute two additional evils of the Power Age. The one leads to an alarming mortality in diseases of the respiratory system, the other to the exclusion of sunlight with its health-giving ultra violet rays, and to a general environmental ugliness and depression.

The first effects of introducing the machine into a civilized community are normally disastrous. We have noted in some detail what happened in England. Much the same story could be told of Japan, India, China, today.

By and large the impact of the machine on nature peoples has been an unrelieved story of progressive degeneration. Firearms, factory rum, and ready-made clothes, with their concomitants, have corrupted every littoral upon which they have landed.

Effects both good and evil

Population has increased and migrated on an unprecedented scale during the course of the industrial revolution. The increase has been due more to a declining death rate than to a growing birth rate. Indeed the birth rate in the West has tended to recede in the past few generations. I see no great virtue in a gross increase in population, and a number of reasons why it is to be deplored. Migration is frequently a wholesome phenomenon, but the greatest migration of all—from farm to city—has undoubtedly been over-stimulated.

The machine has brought community self-sufficiency to an end. This makes for greater productive efficiency when everything is going well, and for greater social disaster when everything is going ill. The reason the White armies were not able to subdue revolutionary Russia lay in the fact that the exposed nerves were few—each village could, in a pinch, maintain itself unaided. No such survival is now possible in the United States.

Machines uproot old skills, but create new ones. The new may often lack the craftsman's individual touch, but they give the modern youngster a greater variety from which to choose. Occupations like that of the locomotive engineer, the hook and ladder man, the airplane pilot, the "steel bird," provide plenty of scope for romance, mystery and danger.

The machine has deprived the housewife of her sometime skills, and so forced uncounted women into futility and neurotic unrest. It has also forced women into the wage-earning class, and thus launched the feminist movement. Feminism is hardly an unmixed blessing, but it will undoubtedly show a net gain in the ledger of history.

The factory puts women and children to work under conditions which are frequently intolerable. But if conditions are made tolerable—as they can be—it is possible to regard machinery as something of a benefactor in providing useful work for whole classes hitherto restrained therefrom by physical handicaps. Children, of course, should be kept out of industry—except as a part of their regular schooling.

In the mass-production industries, a man may earn as much at twenty as at forty—quite possibly more. This upsets all known traditions, but I am not sure it is necessarily an evil thing. Youth has greater capacity to enjoy a good income.

The Power Age has broken up the *mores* of marriage, the family, religion, to a marked degree. This is a painful process, but perhaps invigorating.

Quantity production in goods and printed matter has made for uniformity over a wider area than has obtained in any previous culture—save possibly that of China. This uniformity, however, is subject to frequent and drastic change. Nothing has really crystallized, and the charge of standardization, historically considered, is something in the nature of a false alarm. That much of the uniformity obtaining at any given moment is oppressive cannot be denied.

The machine has ruthlessly destroyed a whole age of art, but is busy creating a new age, which already, in architecture and design, has achieved distinction. The process furthermore is by no means complete; give the machine a few more decades.

The quality of certain goods has fallen, while the quality of others has improved. If the machine is kept within its technological limits, it can provide a whole new budget of useful, durable, and even beautiful products. Regard an ocean liner, a well-built motor car, an airplane. We also note the beautiful mechanisms employed to turn out terrible trash—for instance the broadcasting control-board, with a cheap politician before the microphone.

We tend to draw our knowledge increasingly from written documents and decreasingly from first hand experience—as did the guild apprentice. This divorces us from reality, but gives us wider scope. Where the balance lies I do not know. Undoubtedly much good has come from teaching the last man to read—but then again, regard what he is normally reading. The illiterate reads the seasons and the stars; the literate the tabloids and baseball scores.

Life moves faster than it ever did; there is far more to experience, and rather less emotional ability with which to experience it. Compare the accounts of the travels of Marco Polo with those of Mr. Aldous Huxley. Some fundamental capacity to savour life is missing from the emotional makeup of Mr. Huxley and his friends. They know too much and do not feel enough. The machine has overeducated them. It overeducates many of us.

When the workman left his cottage and his shop for the factory, he lost his economic independence. He gave up his own tools, and operated tools owned by somebody else. He ceased to control his own time and his own job. So long as the force which owns the factory has no interest in labour save as a commodity, the workman is distinctly worse off than before. If, however, the force, as is now the case in Russia, and among certain employers elsewhere—regards the workman as a human being for whose benefit the wheels of industry are principally turning, he may well stand to gain more than he has lost. Goods can be produced with less labour by the machine, and in no other way can his standard of living be markedly increased. In the last analysis more economic independence is to be secured in a machine technology, humanly controlled, than ever obtained in the handicraft era.

There is some overlapping in the above lists, but it is inevitable. All items are part of one organic phenomenon—prime movers clanking about in the social structure. The reader must draw his own conclusions, but as I study the schedules, I incline to the belief that machinery has so far brought more misery than happiness into the world. It has, however, brought the fresh winds of change; and with them, vitality and invigoration. We are not in the lock-step of the Middle Ages or of the later days of Egypt. With change, improvement is always possible. The trend is towards improvement in many departments. If the triple menaces of war, technological tenuousness and failure of natural resources can be forestalled, and some sort of conscious functional control inaugurated, perhaps in another generation the net balance may fall on the other side.

Of the evil effects which we have noted, not all are due to the fact of mechanization, but rather to the manner in which it has been used. Gasoline is a good thing, but not when used to light the kitchen stove. Is it possible to segregate those evils which are implicit in the machine itself from the more or less extraneous evils which have been created by its human direction—or lack of direction? (By mechanization, I mean of course, the billion horsepower, the factory system, mass production, the automatic process, the whole technology so far achieved.)

The machine at its hypothetical best

The Russians today are intensely interested in machinery. Their announced policy is the mechanization of the country as rapidly as may be. (After Lenin, their patron saint is Henry Ford.) Let us suppose that they succeed in this ambition, and within a reasonable historical period achieve their share of the world's prime movers, factories, adding machines, turret lathes, motor cars and belt conveyors. Let us suppose furthermore that their announced policy of operating all mechanisms with an eye single to the benefit of the wayfaring man, is maintained unimpaired. Finally, let us suppose that the several boards and committees intrusted with the job of carrying out these policies are composed of intelligent and honest men and women.

Granting these generous assumptions, we should obviously have mechanization functioning about as well as could be humanly expected. All perversions and misuses drop out of the picture; the only evils still surviving are those inherent in the structure, irrespective of its control. If you do not like to visualize Russia, you are welcome to take any other country, granting only full mechanization, and a functional control thereof. It is assumed that the nation is still short of an international control. The inherent dangers would be cast something in this order:

Mechanized warfare.

The margin of inevitable technological tenuousness.

The divorce of the trinity of work, play and art, following the mandatory process of specialization.

The substitution for old skills of new ones of possibly a less rewarding nature.

A certain amount of social maladjustment due to the inevitable breakup of the time-honoured folkways of marriage, the family, religion.

The speeding up of life—which cannot be avoided until the proper tempo is formed by a long process of trial and error.

The creation of a small robot class. Mechanization, however automatic, demands a certain number of such workers.

Possibly a greater ratio of mental diseases, due to the fact that certain individuals cannot adjust to the mechanical process.

More geographical uniformity at any given time in dress, habits, manners, and a faster turnover in such standards.

A possible softening of racial stock due to high levels of comfort long maintained.

The above are the probable penalties which any people accepting machinery, even under the best of conditions, must face. They are serious, but I confess I see nothing in the list to cause us to turn our backs, with Mr. Oswald Spengler, upon machinery forever. The worst of all is war, but that is subject to control if the mechanized nations can be shocked into making the effort. Certain of the other items, such as change in skill, speed, uniformity, too much comfort, can also be controlled through a long period of intelligent experimentation, though nobody knows how to control them yet. If and when such controls are inaugurated, the danger from mental diseases will undoubtedly be diminished.

Indeed, in the last analysis, only two outstanding difficulties seem to remain—the margin of technological tenuousness which is inherent in the structure in a basic sort of way; and the specialized occupations, including a few in the robot category, which also appear to be basic. A man, however, is said to be a superior organism to a jellyfish. It may be that a social organism with a highly developed nervous system will be found superior to a jelly fish society with no nervous system at all.

When it comes to specialized occupations, I confess to serious perplexity. If these can be proved biologically harmful in the long run, we may have to discontinue a large section of the factory system, and go back to handicrafts—with electrical equipment to aid us—

for many commodities. There is no sense in using a system to maintain a high standard of living if the life process itself is being undermined. Programs like that of Mr. Benton MacKaye for regional planning, already include a handicraft revival in a decentralized industrial structure, fed by unlimited cheap power. Such may provide the solution for this last baffling item.

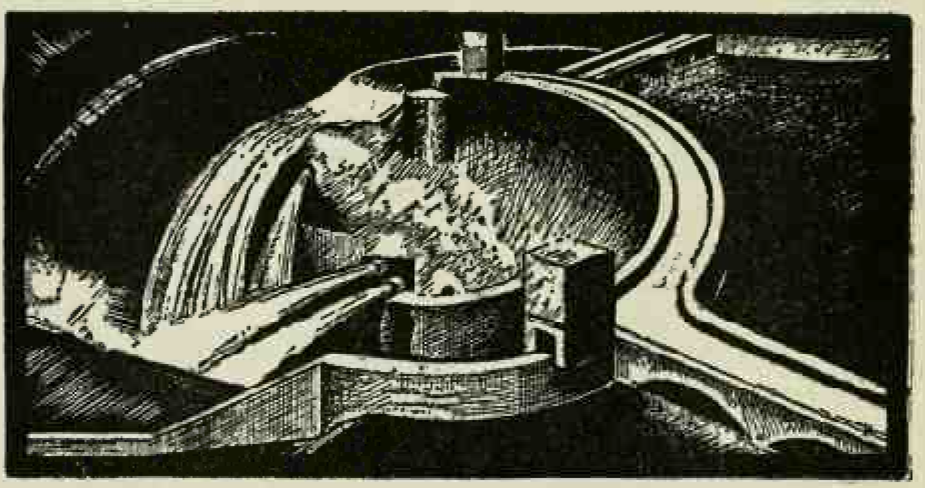
If you take all the evil effects shown on the second and third lists, and deduct the items shown on the fourth and last, you secure an inventory of evils due to the manner in which the machine is at present operated, rather than those inherent in the machine itself. I will save the trouble of making the subtraction by naming the worst of them.

> Too many machines; excess plant capacity; riotous waste of natural resources.
>
> Too much labour in distribution and the overhead services.
>
> Unemployment, cyclical and technological.
>
> A badly balanced flood of goods, often useless, often adulterated.
>
> Super-congestion in urban areas.
>
> A devastating ugliness in many regions.
>
> Smoke, noise and dust in needless volume.
>
> Over-mechanized play.

The only offset to the losses suffered when the machine runs without functional control is a possible greater rate of innovation, invention and promotion. It does seem rather costly, however, to burden a community with such grievous additional loads as those just listed in order that a handful of inventors—or better their promoters—may make a great deal of money, and quite possibly increase the factor of technological tenuousness into the bargain. It may be argued that applied technology would never have progressed had it been subject to functional control. This may or may not be true, but suppose that it is. Would it not be a moderately good idea to organize and utilize the present quite considerable volume of invention for the general benefit of mankind, even at the price of a somewhat lower invention rate—say seven new discoveries a week, rather than fourteen? I am willing to put off that promised trip to Mars for a few years, in exchange for a city planned for comfortable and civilized living. As a matter of cold fact, many technicians do not hesitate to affirm that they could do better work if they were not constantly impeded by the profit motives of business men.

The machine of itself brings certain dangers and certain benefits. To my mind the latter outweigh the former. The machine as currently utilized brings a whole train of additional dangers with no corresponding benefits, save a possible expansion in the invention rate. When the two black lists are added together, the dangers outweigh the benefits. If, however, current usage can be modified to give the machine the maximum chance to prove its worth, the scale comes heavily down on the plus side. Russia has a chance to apply such modification, but she has not much in the way of a technical plant to apply it upon. Other nations, particularly the United States, have the technical plant, but very little desire to modify it on the part of those who are in a position to bring about the necessary adjustments.

But most important of all, granting all the will in the world, is a functional control possible; is the human brain capable of directing the billion horses so that they shall not constantly break into wild stampedes?



CHAPTER XIX

A BILLION WILD HORSES

A DEGENERATIVE molecular disease has attacked steel columns and girders, threatening the housing and transportation of the nation. . . . With fifty million motor cars on the roads, traffic in the Republic has congealed, moving with the dignity of a glacier, and food supplies can no longer reach the inhabitants of great cities in adequate quantities. . . . Suddenly, one urban person in three becomes totally deaf, while the insanity rate has doubled in a year, and threatens to double again. . . . Without warning, salt water invades the oil fields of Colombia, ending the world's last great reservoir of petroleum; new sources of power must be developed, and that immediately.

Choose your crisis. One of the first magnitude has been reached. An aroused and terrified population has renounced whatever forms of democracy it theoretically possesses, created an absolute dictatorship and given it into the hands of one man. Assume for a moment that you, dear reader, are that man. You are enjoined not only to end the emergency, but to take steps to end all probable future emergencies arising from technological causes. You are tendered a Rodeo to run, with a billion wild horses in the ring.

The Graybar Building in New York is turned over to you, for of course you will operate where the live nerves gather, rather than from a remote centre like Washington. You settle the immediate crisis, as could any intelligent and competent individual wielding unlimited power—though we will grant that there has been a certain finish about your performance that is unique. Whatever must be done forthwith, is done.

But now your real work begins. You have to eliminate the machine from all areas where it does not belong; where its presence is over-dangerous, either because of the generation of possible cataclysms, or because of slow degenerative wear and tear on the social structure. You have to find out where those areas are. Having found them, you have to lay down principles for permanent control. Finally, you must exert that control until the process is running smoothly enough to be taken over by more democratic auspices. A few interesting years are thus ahead of you. Let us pray that you survive them.

Far be it from a statistical Don Quixote to instruct the Dictator in his duties, but if you should honour me with an unofficial conference behind the battery of television telephones upon your desk, I might make a few respectful and highly tentative suggestions. You ask me where the machine does not belong. Thumbing, with some trepidation, the pages of this book, I give, subject to further research and verification, the following advice:

You must take the lead among your fellow rulers in relentlessly suppressing war machines.

You must resolutely check the blind and furious activity of machines in the erection of cities already over-congested, and whose nerves are over-exposed, and transfer that energy to a program of decentralization and regional planning. (Mr. J. Russell Smith and Mr. Benton MacKaye can give you sound advice in this connection.)

You must eliminate pumps, steam shovels, tractors and all other mechanical equipment from mines, wells, forests and cotton fields until those which remain exert only a reasonable and prudent drain upon natural resources. The phenomenon of "over-production" must be liquidated.

You must seriously inaugurate, for the first time in history, the deliberate policy of allowing labour-saving devices to save labour—*every factor taken into consideration.* This means that the bloated facilities of distribution must be deflated in favour of an efficient, straight-line system. It means the withdrawal of all machines and all power which now stimulate cross-hauling, super-salesmanship, competitive advertising, and other agencies wasting labour in the march of commodities from factory door to ultimate consumer.

You must forbid machines to make flimsy or adulterated goods. You must eject them from all manufacture of near-art objects. You must limit their function in providing passive, rather than active forms of recreation. While any mechanism caught over-speeding in the realm of styles and annual models shall be drastically slowed down.

Safety devices must be placed on all dangerous machines, in respect to either potential accidents or industrial diseases. Those whose basic design is dangerous beyond the limits of reasonable control shall be beaten into plowshares and tractor-parts.

Haste on the part of any machine—however praiseworthy from the standpoint of efficiency—to supplant workers faster than you can relocate them or adjust their hours of labour, shall be punished by a prompt withdrawal of lubricating oil.

Finally, no worker shall permanently operate a mechanism until he has been tested as to his physiological and psychological fitness. Machines which give negative reactions in all cases tested—however ingenious, however costly, however efficient—shall be melted down in the nearest blast furnace.

These are my initial suggestions in respect to the areas where machines do not belong, or where their activity should be curtailed. If your patience is not exhausted, I can offer one or two more covering the technique of control. The first has haunted my imagination for many years.

Not far from your inner office should be a room seating perhaps a hundred persons. One whole wall of this room is given over to a map of the United States, traced in glass, and capable of intense illumination from the rear. Behind the glass outline is a solid field of tiny glass bulbs, preferably in various colours. Competent electricians elaborate a switchboard, whereby various combinations of these bulbs can be lighted; the purpose being to throw upon the map the outlines of the social and industrial resources of the country. The bulbs will etch state boundaries, population clusters, river systems, coal beds, railway lines, power lines, forests, farm lands, oil fields, irrigation projects, educational and research centres, textile plants, cotton fields, highways, copper mines—or anything you please. Different lights are advisable in order that two or three activities may be plotted simultaneously. A button is pressed, and the textile industry appears in green. Another, and cotton fields appear in white. Another, and consuming centres appear in red. Thus any industry can be oriented with any other, and both with the social factors involved. It is a complicated mechanism to devise, but not more so than an automatic railway switch yard, and you have before you the most complicated problem which any human being ever faced. I think that you and your technical advisors can study such a coördinating map to great advantage. Obviously, before it is used, reliable statistics must be gathered. Much of the data is now available in the office of the Census, the Geological Survey, the trade association tabulations, but many blanks remain to be filled—of which unemployment figures are the most shameless omission.

If I may be permitted, I should advise you to lose no time in securing a firm grip upon two industrial departments—natural resources, and prime power sources, particularly central stations. With these in hand, you accomplish the strategy of stoppage at source; hardly a wheel can turn save at your bidding. This control should be utilized to close down high-cost units in over-equipped industries—allocating their personnel to keep low-cost units operating at capacity, and so further reducing their costs. If the personnel is more than sufficient, shorten hours.

Permit resources and power to be used only by employers who show clean hands: that is, a necessary article or service, reasonably well made by methods which impose no physical or mental degeneration upon employees. Fatigue curves, and the excellent ground work of the Safety Council, will greatly facilitate your decisions here.

Stimulate new invention by shifting capital from the more intricate ramifications of say the tooth paste traffic to great laboratories for serious research; and further by protecting inventors—an innocent and gullible race —against the short shrift normally granted them by promoters. In this connection it will be well to conduct a thorough raid upon the closeted inventions of various large corporations, and inventory the social value of putting such patents into immediate technical operation.

Encourage all industrial activities which require skilled work, as against routine and repetitive processes. At the same time, speed up the development of the automatic function, replacing robots with skilled designers and maintenance men. In your decentralization program, it may be well to provide for a certain amount of local handicraft, aided by electric motor, in order to keep citizens interested in the output of their own hands, and also to stimulate a new Power Age art. Remember that leisure without interest is a boomerang. *Homo sapiens* is a busy, exploring, contriving animal. If any considerable group of machines completely deprives him of this faculty, put a stop signal on its oil supply.

Delegate few executive functions to any lawyer, actor, banker, orator, professional labour leader, professional politician or professional radical. The exigencies of their trades have deprived such persons of their perspective and power to deal with concrete realities—potent as may be their dealings in the realms of metaphysics or emotion. Machines, like horses, can be tamed only by men who understand them. You must find your staff among engineers, architects, scientists, air pilots, physicians, surgeons, skilled machinists, plant foremen, and among the younger business men not yet undone by too close an association with the sales department. You can pick up a good staff officer here and there in the old government services, such as the Bureau of Mines or the Bureau of Standards, and, surprising as it may seem, here and there in the colleges. (Which reminds me that another early step should be to lift about one hundred million dollars out of the cosmetic industry and apply it to the salaries of university professors.) You had best place little confidence in journalists and authors, though a poet and painter or two might be used to salt the more unimaginative moments of the engineers. Advertising men with sufficient irony as to their former activities can be well and happily employed in promoting great campaigns for public health, safety and education.

It is difficult enough to attempt the control of the physical machine, without tolerating any misbehaviour on the part of the financial system. This elaborate structure, compounded of a few behaviour patterns and a great many pieces of paper, is, in the last analysis, nothing more than so much wind. Its present power is tremendous, but so are the charms of an African conjurer. You must use it at the outset to secure unlimited credit and a high volume of purchasing power to tide you over the reconstruction period. Ultimately it should take its place far below that of engineering, as a simple and adequate medium of exchange.

And for this reason. Money and credit take on great importance in an economy of scarcity, as is perhaps inevitable. Such was the only economy history had to record before 1900. But in the economy of abundance which you are now inaugurating, with the billion horses really saving labour and rapidly raising the standard of living for the entire population, the importance is bound to decline. If there is more than enough to go around, and no spectre of poverty or of economic insecurity, the piling up of private fortunes, and the system which has hitherto permitted them to pile up, become reasonably pointless. Both the driving need for individual material security, and the desire to secure prestige through great accumulations, are necessarily undermined in a community where everyone is well-to-do. Riches can preen its feathers over poverty, but not over universal wealth. Prestige will have to be sought in other, and possibly nobler, channels.

In some such fashion you marshal your forces, and dispatch your orders from the Graybar Building—a building presently to stand bathed in sunshine, surrounded by plazas, lagoons, and shade trees. In some such fashion the State Planning Commission is now starting to function in Russia; and the British Liberal Party, by virtue of its program published in 1928, hopes to induce England to function in the future. (But Signor Mussolini, it appears, has other ends in view.) Many vested rights will be seriously disturbed, many soft berths demolished; the scions of many fine old families will have to go to work. Nor can I answer for the tumult on the stock exchange—so you had best declare a moratorium. There will be many anxious days to begin with; but so long as the billion horses pull, the economy of abundance functions technologically, and mass purchasing power is released in sufficient volume, there is nothing fundamentally to fear. You can cheerfully carry your work forward, while the lights flash white, red and green, on your great glass map.

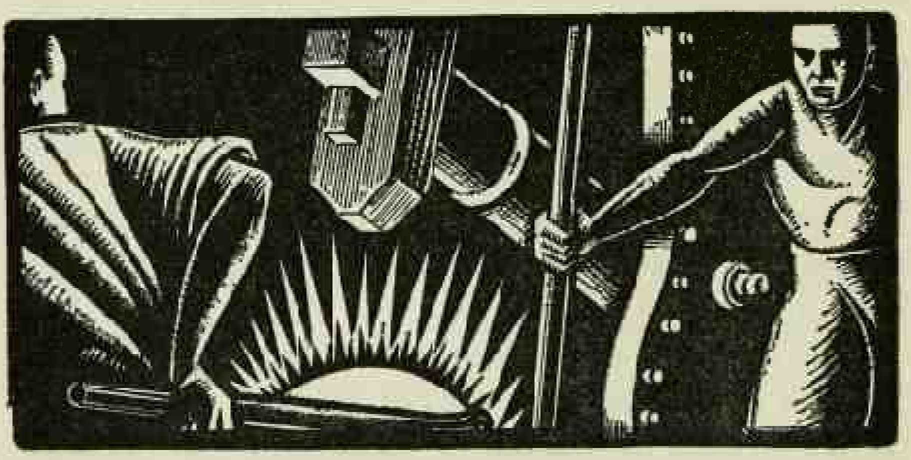
A pretty picture if you like, but only a picture. Even you, dear reader, would fail as the Dictator. I sketch its outlines solely to show the terms upon which the machine can be expected to capitulate. If we do not like these terms—and most of us do not—well and good. The machine continues to revolve in its own race track, breeding and expanding according to laws which we do not even understand; unbroken and untamed. While we continue as best we may to dodge the wheels of that orbit—working harder, playing less, worrying and suffering more than there is the slightest necessity save blind stupidity for doing. We must continue to dodge the wheels until some time within the next generation a lesion so unbelievably drastic impends that we may be forced to accept these terms, however reluctantly; until, indeed, a practical dictatorship is thrust upon us.

What that dictatorship will be, I have no clear idea. Perhaps a super-trust, coördinating all big business in corporate form, and undertaking the task for a flat eight per cent on its own new issues, in which all other corporation stocks and bonds of vital value will be funded. Perhaps a group of embattled technicians will come to the fore organized along the lines of Mr. Wells' "open conspiracy"—men and women who have faced the problem of functional control and are willing to try to put it into tangible operation. Perhaps a working class revolution. Perhaps a very strong, theoretically constitutional President, with a compact congressional majority in back of him—something on the order of Mr. Woodrow Wilson during the War.

Perhaps, indeed, the lesion will never come and no dictatorship born of a crisis arise. This eventuality is remote but conceivable. It is far from certain, however—despite the various encouraging factors which these pages have recorded—that a policy of drift furnishes any insurance whatever against social decay. The case of the gloomy prophets has been adjusted and corrected, but it has not been disposed of. The fruits of a wise dictatorship must somehow be achieved, if by a longer and less drastic road. Man is not the slave of his machines, but he has allowed them to run unbridled, and his next great task is, by one method or another, to break them to his service.

I see before us three alternatives. We can drift with the tide as at present. We can officially adopt some simple formula like "government by business," or "state socialism," and thus attempt to run a dreadnaught with a donkey engine. Or we can face the full implications of the machine, relying on no formulas because none adequate have been created, with nothing to guide us but our naked intelligence and a will to conquer.

The stars, alas, predict the first; Russia proved the futility of the second when the Marxian formula gave way to the New Economic Policy, which is another name for pragmatism; the last is the great adventure—the boldest, most exhilarating, most dangerous adventure that ever challenged the intelligence and spirit of mankind. From our brains have sprung a billion horses, now running wild and almost certain sooner or later to run amuck. Where are the riders with their whirling ropes; where the light-hearted youths to mount, be thrown, and rise to mount again?



SELECTED BIBLIOGRAPHY

American Engineering Council, *Safety and Production.* 1928.

Andrade, *Engines.* 1928.

Barnes, *Living in the Twentieth Century.* 1928.

Barnett, *Machinery and Labor.* 1926.

Beard, *The Industrial Revolution.* 1901.

The Beards, *The Rise of American Civilization.* 1927.

Beard and Others, *Whither Mankind.* 1928.

Borsodi, *This Ugly Civilization.* 1929.

Bowden, *Industrial Society in England.* 1925.

Britain's Industrial Future (Liberal Party Report. 1928).

Burr, *Ancient and Modern Engineering.* 1907.

Butler, *Erewhon.*

Dana, *Human Machine in Industry.* 1927.

Ford and Crowther, *Today and Tomorrow.* 1926.

Fox, *The Triumphant Machine.* 1928.

Frank, *sundry articles in "Labor Age."* 1928-29.

Freeman, *Social Decay and Regeneration.* 1921.

Gaillard, *Mass Production, Annals.* May, 1928.

Gantt, *Organizing for Work.* 1919.

Garrett, *Ouroboros.* 1926.

Gibbs, *The Day After Tomorrow.* 1928.

Goldmark, *Fatigue and Efficiency.* 1913.

Haldane, *Possible Worlds.* 1928.

The Hammonds, *The Rise of Modern Industry.* 1926.

Hobson, *The Evolution of Modern Capitalism.* 1926.

Kellogg, *articles on Ford in "Survey Graphic."* February and March, 1928.

Kenworthy, *Will Civilization Crash?* 1927.

LIPMANN, *The Human Factor in Production, "Personnel Research Magazine."* August, 1928.
THE LYNDS, *Middletown.* 1929.
MACKAYE, *The New Exploration.* 1928.
MEAD, *Coming of Age in Samoa.* 1928.
MERZ, *The Great American Band Wagon.* 1928.
MYERS, *Industrial Psychology.* 1925.
Publications of the National Institute of Industrial Psychology. 1924-29.
OGBURN, *Social Change.* 1922.
POUND, *The Iron Man in Industry.* 1922.
REEVE, *Modern Economic Tendencies.* 1921.
RICHBERG, *Feeding the Iron Hog.* 1927.
SIEGFRIED, *America Comes of Age.* 1927.
SIMONDS AND THOMPSON, *The American Way to Prosperity.* 1928.
SPENGLER, *The Decline of the West,* Vol. II. 1928.
TUGWELL, *Industry's Coming of Age.* 1927.
TUGWELL AND OTHERS, *American Economic Life.* 1925.
VEBLEN, *The Engineers and the Price System.* 1921.
WARSHOW AND OTHERS, *Representative Industries in the United States.* 1928.
THE WEBBS, *The Decay of Capitalist Civilization.* 1923.
THE WEBBS, *Industrial Democracy.* 1920.
WILE AND OTHERS, *A Century of Industrial Progress.* 1928.
ZIMMER, *Engineering of Antiquity.* 1913.

INDEX

Accidents, 152, 324.
Accuracy of machines, 99.
Aesthetics, 280.
Agriculture, 324.
Airplanes, 101, 307.
American Engineering Council, 153.
American Machinist. See Colvin.
American Standards Association, 275.
Andrade, E. N., 27, 34.
Antelope, wreck of the, 169.
Archimedes, 50.
Architecture, 240.
Art, 247, 328.
Atlantic Monthly, 200.
Atomic energy, 34.
Austrian Engineering Association, 212.
Automobile man power, 187.

Babbage, Charles, 206.
Bacon, Roger, 58, 67.
Barnes, Harry Elmer, 18.
Barnett, 149, 174.
Beard, Charles A., 16, 172.
Behaviour standards, 278.
Bell, Alexander Graham, 39.
Benefits of the Power Age, 319.
Benét, Stephen Vincent, 267.
Bentham, Sir Samuel, 100.
Birth rate, 326.
Bombs in warfare, 307.
Borsodi, Ralph, 143, 191.
Boston and Maine Railroad, 211.
Boston Edison Company, 156.
Brady, Robert, 248.
Breasted, 49.
Brown and Sharpe, 99, 101.
Butler, Samuel, 10, 130.
Byrd, Commander, 144.

Cartwright, Dr. Edmund, 71.
Charity, 321.
Chukhnovsky, 144.
Cignot, Joseph, 75.
Clark, Evans, 210.
Clark Thread Company, 154.
Class distinctions, 269, 320.
Claude, Georges, 35.
Clocks, 59.
Coal, 304.
Columbia University, 267.
Colvin, Fred, 160, 173, 177.
Commerce, Department of, 209.
Commercialized amusement, 258, 264.
Communal independence, 326.
Comparative activities, 284.
Competition, 323, 339.
Congestion, 339.
Conservation, 342.
Consumer's dilemma, 234.
Contacts with machines, 114.
Copper, 304.
Cox's Museum, 70.
Craftsmanship, 326, 342. *See also* Handicraft, Skill.
Cruden, R. L., 162.
Culpin, Dr., 156.

Dangers of machines, 286.
Death rate, 326.
Decimal system, 41.
Decreation, 256.
Dewey, John, 18, 267.
Dialects, 267.
Diogenes, 218.
Disraeli, 15.
Distribution, 192, 339.

Drake, Colonel, 81.
Dubreuil, 160.
Du Pont Company, 154.
Durant, Will, 17.
Dust, 325.

Economic independence, 329.
Education, 280.
Efficiency of machine work, 194.
Egypt, 42.
Electricity, 77.
Ellis, Havelock, 260.
Enclosure Acts, 125.
Engines, 27.
Evening Standard (London), 269.

Faraday, Michael, 77.
Fatigue curves, 163, 342.
Feminism, 326.
Finance, 344.
Fisher Body Corporation, 178.
Fisheries, 306.
Fitness of labourers, 340.
Flood-control in Egypt, 47.
Ford, Henry, 15, 25, 94, 98, 103, 143, 158, 173, 194, 212, 297, 331.
Forster, E. M., 11, 39, 292.
Frank, Dr. Herman, 158.
Frank, Waldo, 263.
Frankenstein, Dr., 14.
Freeman, Austin, 12, 19, 171, 229, 242.
Frost, Rev. Henry P., 14.
Fulton, Robert, 76.

General Electric Company, 98.
General Motors, 179.
Geological Survey, 92.
Gibbs, Philip, 15, 298.
Goods, classes of, 223.
  quantities in use, 226.
Goodyear, Charles, 84.
Greece, 49.
Gunpowder, 59.

Habits, machine made, 118.
Haldane, J. B. S., 15, 35.
Hammond, J. L., and Barbara, 130, 132.
Handicrafts, 175. *See also* Craftsmanship, Skill.
Health, 148.
Henry, Joseph, 80.
Hero, *Pneumatica,* 53.
Home expenditures for machines, 218.
Hoover, Herbert, 223, 306.
Hubbard, Henry, 17.
Human equation, 322.
Huxley, Aldous, 329.

Income, 327.
Indictments of the machine, 9.
Industrial Fatigue Research Board, 163.
Industrial Psychology, National Institute of, 164.
International Labor Review. See Rabinowitz.
International relations, 320.
Inventions, 70, 73, 78, 342.
Iron, 304.

Justification of the machine, 15.

Kenworthy, J. M., 309.
Kitson, Professor, 164.
Krupp Works, 88, 100.

Labour Department survey, 161.
Labour distribution, 189.
Labour-saving, 183, 206, 339.
Lapoule, Albert, 310.
Lee, Gerald Stanley, 17.
Lehman and Witty, 262.
Leisure, 320.
Lenin, 331.
Leonardo, 61, 67.
Lewis, Wyndham, 60.
Lindbergh, Charles, 144.
Linotype, 150.
Living standards, 319.
Longevity, 319.
Low, F. R., 91.
Lubin, Isidore, 215.

Lumber, 305.
Lynd, Mr. and Mrs., 122, 183, 235, 281.

MacKay, Donald, 101.
MacKaye, Benton, 253, 334, 339.
Machines, adoption in the home, 227.
  common, 109.
  definition of, 24.
  distribution of, 220.
  functions of, 36.
  major parts of, 26.
  optimum conditions for, 331.
Machine work versus hand work, 194.
Manufactures compared to population, 221.
Massachusetts Institute of Technology, 8.
Mass production, 93, 103.
Mead, 284.
Menaces of the Power Age, 322.
Mencken, H. L., 266.
Mental effects, 108, 324.
Merz, Charles, 119.
Michell thrust block, 82.
Middle Ages, 55.
Migration, 326.
Mill, John Stuart, 184.
Millikan, Robert A., 34.
Mining, 74.
Money, 139, 323.
Mumford, Lewis, 60, 240, 244.
Mussolini, Benito, 345.
Myers, Dr. C. S., 161.

Natural gas, 303.
Natural resources, 301, 322, 339, 342.
New Bedford textile strike, 297.
Newcomen, 64.
New York Edison Company, 106.
New Yorker, 290.
Nicholson, Professor, 172.
Noise, 325.
Obsolescence of machines, 81.
Ogburn, W. F., 18, 77, 155.
Over-specialization, 287.

Papin, Dr., 54.
Paralytic trades, 299.
Patten, Simon, 181.
Peel, Robert, 128.
Penalties of the machine, 332.
Perpetual motion, 57.
Petroleum, 81, 303.
Petroleum Conservation Board, 303.
Play forms of children, 262.
Pliny, 51.
Plutocracy, new, 323.
Poison gas, 309.
Polakov, 164.
Pope, Colonel, 101.
Population compared to manufactures, 221.
Population congestion, 137, 324.
Pound, 133.
Power, 91.
Power sources, 342.
Printers' Ink. See Rowe.
Propaganda, 268.
Public Information, committee on, 268.
Pyramids of Egypt, 45.

Quality of goods, 228, 232, 327, 340.

Rabinowitz, 175, 179.
Read, T. T., 89.
Reading Railroad, 263.
Reaumur, 84.
Recreation, 254.
Redpath-Scott, W., 269.
Reforms, 134.
Religion, 278.
Renaissance, 63.
Repetitive work, 159, 322.
Research, 321.
Robots, 3, 142, 147, 181, 211.
Roosevelt, Theodore, 287.
Rome, 51.
Rowe, Brian, 230.

Russell, Bertrand, 15, 49.

Sachs, Albert Parson, 16.
Safety devices, 340.
Savery, Thomas, 64.
Schlink, F. J., 275.
Science, beginnings of, 57.
Sears Roebuck, 276.
Selling cost, 199.
Sexual standards, 279.
Siegfried, 104.
Silvester II, Pope, 67, 69.
Sinclair, Upton, 266.
Skill, 171, 180. *See also* Craftsmanship, Handicraft.
Smith, Adam, 127, 293.
Smith, George Otis, 302, 304.
Smith, J. Russell, 305, 339.
Smoke, 325.
Social standards, 124, 325, 327.
Soddy, Professor, 15.
Soils, 305.
Specialization, 139, 170, 322.
Spengler, Oswald, 14, 333.
Spinning and weaving, 71.
Sprague, Jesse R., 199.
Standardization, 270, 327.
Standards, commodity, 275.
  industrial, 273.
  social, 278.
Steamboat, 75.
Steam engine, 64.
Stephenson, George, 75.
Stewart, Ethelbert, 214.
Stocking, G. W., 298.
Stone Age, 19.
Structure of a machine, 20.
Submarines, 311.
Superstition, 320.
Symington, William, 75.

Taylor, Frederick W., 83, 158.
Taylor, Horace, 214.
Technological tenuousness, 286, 322.
Technology, 292.
Televox, 106, 148.
Thermodynamics, laws of, 28.
Trevithick, Richard, 75.
Tryon, F. G., 90.
Tugwell, R. G., 91.
Tunis, John R., 258.

Unemployment, 205, 323, 340.
Union Pacific Railroad, 154.
United States Steel Corporation, 154.

Van Loon, Hendrik Willem, 49.
Veblen, 299.

Warfare in the future, 286, 307, 322.
War machines, 339.
Watt, James, 4, 12, 25, 64, 107, 157, 241.
Webbs, The, 125.
Wells, H. G., 15.
Westinghouse laboratories, 106.
Whitney, A. W., 273.
Whitney, Eli, 72, 98, 100.
Winslow, C. E. A., 149.
Wonderful Magazine, 69.
Worcester, Marquis of, 54.
Workers, absorption of, 213.
  decline of, 210.
  fatigue of, 162.
  insecurity under mass production, 212.
Working conditions, 321, 327.

Xenophon, 50.

This book may be kept
Fourteen Days
A fine of two cents a day
will be charged for each day
the book is kept overtime.

Due	Due	Due	Due
DEC 12 '38			
Ja 4 '39	JE 17 '48		
Ja 4 '39	JY 1 '48		
Ap 11 '39			
My 5 '39	MR 15 '48		
My 22 '39 F 17 '40	JE 4 '48		
Mr 18 '40	MR 9 '50		
O 22 '41			
My 19 '42	FEB 26 '51		
D 2	JUN 4 '51		
DE 20 '45	DEC 13 '54		
AP 3 '46	MAR 11 '62		
AP 12 '46	FE 2 [illegible]		
AP 24 '46			
MY 31 '46			

LEISURE READING

FORM 2 11-22-37 5M

12175 338.4
C487

Chase, Stuart.
Men and machines.